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THE STEAMSHIP "VADERLAND" of the Red Star Line has been launched at the yards of her builders, John Brown & Co., Ltd., of Glasgow. This new vessel is the first of four steamers to be built for the above line for service between Antwerp and New York. Her dimensions are: Length between perpendiculars, 560 ft.; breadth, 60 ft.; depth, 42 ft.; gross register, 12,000 tons. Roughly speaking, she is of the same size, though of much greater tonnage, than the "Paris" and "New York." The hull of the "Vaderland" has been specially strengthened, so that her engines may be driven at maximum speed in all kinds of weather. There are eleven watertight bulkheads, so built that flotation could be maintained with any two compartments filled with water. The "Vaderland" will accommodate 342 first-class, 104 second-class and 626 third-class passengers. Estimating the ship's company at 253, there is provision on board for 1,415 persons. With the exception of a space amidships fitted for the firemen, and a similar space aft for the stewards, the holds and 'tween decks are entirely devoted to cargo and stores. The cubic capacity is sufficient for 11,000 tons of cargo, and the fittings of some of the steerage berths are so designed that the compartments may be used for freight purposes when the space is not required for passengers.

THE RADDATZ SUBMARINE BOAT has recently been tested at Milwaukee, Wis. The boat is 65 ft. long and 4 ft. in diameter at the middle and tapers to a point at each end. Near the extremities are two conning towers, each about 20 ins. in diameter. When going on the surface power is furnished by a 10-HP. oil engine, which gives the vessel a speed of six to seven miles per hour. The boat is driven under water by an electric motor supplied from 62 storage cells and attains a speed when submerged of 4 to 4½ miles per hour. The nature of the controlling mechanism has not yet been made public. It is said that the boat will sink to 40 ft., which is as far as it has been tested, in from 30 to 40 seconds. It does not dive nor slant when descending or rising. The boat carries a supply of compressed air and has an apparatus for purifying the air contained in the interior while under water. It is stated that three men could easily remain beneath the surface for 8 hours. It is the intention of the builders to construct a larger boat in the near future.

A NEW TRANS-ATLANTIC RECORD has been made by the Hamburg-American steamer "Deutschland," whose fast maiden trip to New York was noted in our issue of July 19. According to the information sent out from the office of the company in New York the new vessel covered the 3,085 knots between Sandy Hook Light Ship and Plymouth at the average speed of 23 knots, the time being 5 days 14 hours and 6 minutes. The previous best record for the eastward trip was held by the North German Lloyd steamer "Kaiser Wilhelm der Grosse," and was 5 days, 15 hours and 10 minutes.

THE 600-FT. LOCK AT SAULT STE. MARIE is set down for enlargement by the U. S. Engineer Corps, which proposes to take steps at the next session of Congress to secure authority and an appropriation for the work. At present there are two locks on the American side of the St. Marys Falls, one 600 ft. long and 80 ft. wide, which it is proposed to enlarge, and the other 800 ft. long and 100 ft. wide. According to press dispatches it is proposed to make the new lock 100 ft. wide and from 1,500 ft. to 1,600 ft. long, with a depth of 25 ft. on the sill. The estimated cost of the work is $9,000,000.

THE ELBE AND TRAVE CANAL in Germany, was opened by the Emperor of Germany on June 16. It has been under construction for five years, and, according to a consular report, has cost about $5,831,000, of which Prussia contributed $1,785,000, and the old Hansa town of Lübeck $4,046,000. The length of the new canal, which is the second to join the North Sea and the Baltic, following the Kaiser Wilhelm Canal (or Kiel Canal), which was finished five years ago at a cost of $37,128,000, is about 41 miles. The breadth of the canal is 72 ft.; breadth of the locks, 46 ft.; length of locks, 261 ft.; depth of locks, 8 ft. 2 ins. The canal is crossed by 29 bridges, erected at a cost of $1,000,000. The span of the bridges is in all cases not less than 90 ft. and their height above water level about 15 ft.. There are seven locks, five being between Lübeck and the Möllner See (the summit point of the canal) and two between Möllner See and Lauenburg-on-the Elbe.

ELECTRIC TOWING FOR CANALS has been tried on the Finow Canal, in Germany, between Berlin and Stettin. A track of 1 meter gage was laid along the bank of the canal, having one 9-lb. and one 18-lb. rail laid partly on cross ties and partly on concrete blocks. The larger rail serves for the return current and has bolted to it a rack gearing with a spur wheel on the locomotive, the weight of the locomotive being insufficient. The engine is 6 ft. 10 ins. x 4 ft. 10 ins., mounted on four wheels, with a wheel base of 3 ft. 6 ins., and weighing two tons. It is fitted with a 12-HP. motor, current for which is furnished by a 9-K-W. dynamo driven by a 15-HP. engine. The current is of 500 volts, and is transmitted by a wire carried on wooden poles 23 ft. long, about 120 ft. apart. The boats are about 132 ft. long and 15 ft. 6 ins. beam, carrying 150 to 175 tons on a draft of 4 ft. 9 ins. The towing system was installed by Siemens & Halske, of Berlin.

THE LEASE OF THE WATER POWER at the end of the Chicago Drainage Canal by the city of Chicago is still unsettled, the Drainage Board having declined to accept the form of lease as amended by the Corporation Counsel. The city objects to two features of the proposed contract. It disclaims any authority to make a lease for 70 years, or for any period beyond the life of the council entering into a lease. It also objects to a binding agreement to pay $4 per HP. per annum and asks that the rate be adjusted on a sliding scale basis. The corporation counsel has inserted a paragraph in the contract whereby the board of trustees is to reimburse the city for the plant if at any time after a year's notice of abrogation the city gives up the contract. The Drainage Board refuses to accept any such lease or contract with such an indefinite term of existence.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred at Ninnekah, Indian Territory, on the line of Chicago, Rock Island & Texas Ry. on July 20. A passenger train collided head-on with a double-header freight train. Three men were killed and five injured.

THE STEAMSHIP "CAMPANIA" of the Cunard line collided with and sank the bark "Embleton" in a fog in the Irish Channel on July 21. The "Embleton" sand immediately, drowning eleven of her crew, but the "Campania" was only slightly injured. The bark was laden with dynamite, which fortunately did not explode.

AN ELECTRIC RAILWAY IN COREA is to be built by Henry R. Bostwick, an engineer of San Francisco, who has a concession from the government. A highway will be built at the same time, the electric railway being at one side of the road. It will be a 15-mile extension of the present line, which is five miles long, and extends to the imperial cemetery. According to press reports the cemetery is to be moved 15 miles to a new site, and the contract for removing and re-erecting the tombs and monuments has been given to Mr. Bostwick.

"STORAGE BATTERIES FOR SMALL STATIONS" are discussed in a paper read before the recent meeting of the Northwestern Electrical Association by Mr. L. A. Ferguson, of the Chicago Edison Co. His deductions are very interesting and are worthy of being noted. He says:

The cost of capacity in steam and electrical generating equipment is dependent solely upon the maximum power to be generated at any one time, and is not dependent upon the number of hours of use per day of the equipment. In the case of the storage battery, however, the cost is dependent not only upon the maximum energy to be supplied at any one time, but also upon the length of time that the battery is required to do this maximum work. This being the case we must consider carefully the load curve of the station, and if the characteristic of the curve is such that the average width of its peak is more than 1½ hrs., then the initial cost of steam and electrical generating equipment to provide capacity for this peak will be less than that of the necessary storage-battery equipment, at the present market prices, to do the same work. If the curve has an average peak width of less than 1½ hrs., then the initial cost of the storage battery will be less than that of the steam and electrical generating equipment to take care of this peak. The cost of a storage battery of moderate size, taking, for instance, one having a capacity of 500 amperes at the one-hour rate, would be, at the various rates of discharge, approximately as follows: 1 hr., $80 per K-W.; 2 hrs., $116 per K-W.; 3 hrs., $160 per K-W.; 5 hrs., $240 per K-W.; 8 hrs., $320 per K-W. These figures include switchboard, end-cell switches and the battery erected complete, not including building investment. The cost of a steam and electrical generating plant will, of course, vary widely with the class of apparatus employed. Assuming, however, $100 per K-W. as a reasonable price for boilers, engines, steam-piping, generators, stack and switchboard, we find that, where the average width of the peak of the load which is to be taken care of by the storage battery is 1½ hrs., the cost of installation is the same for the storage battery as for the steam plant. The battery has no place, from an economical standpoint, in a small station which has a long peak. A storage battery operated under favorable conditions would show upon test an energy efficiency of 75% and an ampere-hour efficiency of 90%. The yearly energy efficiency of a storage battery operated under ordinary central-station conditions, would, in all probability, not exceed 65%.

A NEW PASSENGER STATION is to be built at Melbourne, Victoria (Australia), at a cost of about $1,000,000, and 17 competitive plans were submitted to a board composed of Messrs. H. Deane, F. Rennick, H. C. Stanley and A. B. Moncrieff (Chief Engineers of the government railways of New South Wales, Victoria, Queensland and South Australia, respectively); with Mr. Lloyd Taylor, Chairman of the Victoria Institute of Architects, and Mr. C. Norman, Engineer for Existing Lines of the Victoria Government Railways. The three prizes of $2,500, $1,000 and $500 were awarded as follows: (1) James Fawcett and H. P. Ashworth, architects in the Victoria Railways Department; (2) Mr. Charles A. d'Ebro, of Melbourne, and Messrs. Wright & Pestell, of Melbourne.——At Brisbane, Queensland, a new union station is being built, at a cost of $250,000. The building has a main frontage of 522 ft., 24 to 48 ft. high, with a clock tower 92 ft. high, built of red brick and white stone. The trainshed will be 100 ft. wide, and 42 ft. high at the center, supported by 12 main girders and 27 intermediate girders.——At Adelaide, South Australia, a new station is also being built, and has a trainshed 400 ft. long, covering seven tracks and six platforms, with a platform 70 ft. wide and 180 ft. long across the end of the station.

THE NEW RAILWAY STATION at Copenhagen, Denmark, will be built according to the plans of Mr. Ambt, of that city, whose designs were accepted from 21 sets of plans entered in competition by a number of foreign engineers. The competition was published in this country, but no American engineers entered. The work will include not only the station building, but also the approaches, yards, etc., and will cost about $6,000,000.

PNEUMATIC CROSSING GATES AND SIGNALS are now being introduced as the result of successful experience with one of these signals on the Delaware, Lackawanna & Western R. R. at Sherburn, N. Y. The air is compressed by a treadle set against the rail, and so arranged that trains backing up simply depress the treadle without operating the compressor. The gates are of the ordinary form, with pivoted balanced arms, but the end sections are attached to the main sections by springs and swivel joints so that they can be forced upward and outward from the track side of the gate. By this means a team accidentally caught on the track by the gates could very easily escape. With two trains passing near a crossing, the one which first runs over the crossing does not raise the gates, which are kept closed until the second train has passed. A similar apparatus is proposed to be applied to an automatic block signal system. The patents are owned by the Lyman Pneumatic Signal Co., 82 Fourth Ave., New York, N. Y.

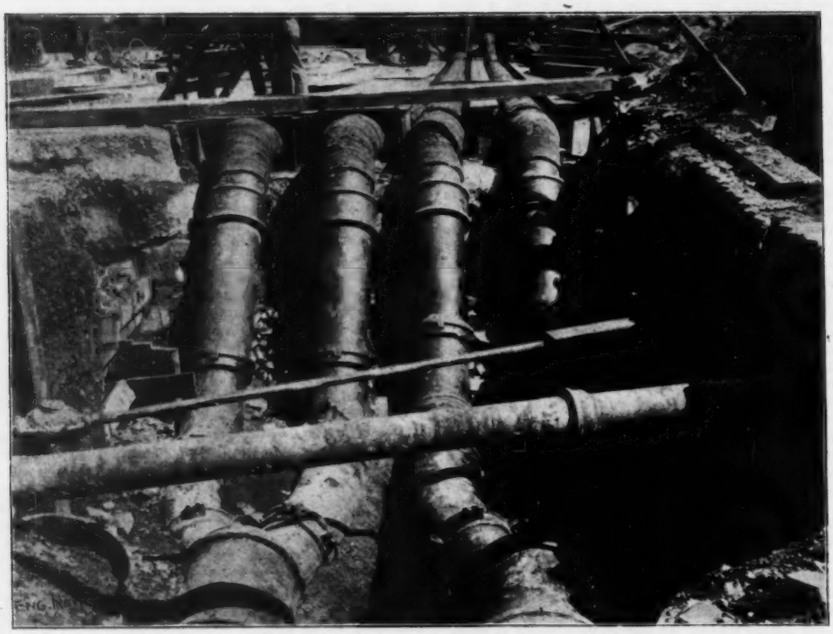
THE LONGEST PIER IN NEW YORK HARBOR is that of the New York Central R. R. at Desbrosses St., which is 840 ft. long from the bulkhead line, though its width is only 80 ft. The five new piers near 12th St., leased to the Cunard, White Star and Wilson steamship lines are 700 to 750 ft. long, 110 to 125 ft. wide. Between 12th St. and 23d St. it is proposed to build nine piers, 800 ft. long, with two-story sheds. Many of the sheds on the present piers are of timber framing, sheathed with wood or corrugated iron, and are thus more or less risky, especially when full of inflammable goods. The newer sheds are of steel framing with iron sheathing.

A HARBOR PROJECT FOR MILWAUKEE, WIS., which has been advocated by the mayor, Mr. Rose, has been reported upon unfavorably. In view of the length of new lake steamers and of the winding character of the rivers at Milwaukee, it was proposed to establish an outer harbor, protected by a breakwater with an entrance 600 ft. wide, and having eight piers extending out into the harbor. At a meeting of the Chamber of Commerce, however, numerous objections were made to any such plan, and it was concluded that it would be more practicable and more advantageous to the city, to widen and deepen the rivers, replace the swing bridges with bascule bridges, and develop the dock property now available in the city.

20-IN. STEEL PIPE SUBSTITUTED FOR 30-IN. CAST-IRON PIPE AT A RAILWAY CROSSING IN BOSTON.

By H. F. Winslow.*

The largest and most extensive change in the water pipe system of Boston, Mass., made necessary by the new railway connection between Dartmouth St. and South Station, along the southerly location of the Boston & Albany R. R., was that at Castle Square. At this point two 30-in. mains crossed the line of the work; and here the Provi-



20-IN. STEEL WATER MAINS AT OVERHEAD CROSSING OF NEW YORK, NEW HAVEN & HARTFORD R. R., CASTLE SQUARE, BOSTON, MASS.

dence Division of the New York, New Haven & Hartford Railway was designed to pass under the street, leaving only 22 ins. as the available height for pipe space.

This height was evidently not sufficient for the 30-in. mains, and it was decided to substitute for them four 20-in. steel pipes at the point of crossing. As the old mains were considerably tuberculated for a long distance in either direction, it was thought that no material diminution of flow would result from the change in size of pipe; and to compensate for any possible loss an auxiliary 12-in. pipe was also laid.

The 20-in. steel pipes were hung from I-beams, and the connection between them and the old 30-in. mains was made with a sleeve and a lead joint, thus providing for any settlement away from the steel pipe. A new bridge was built across the Boston & Albany line, as the necessary Y-branches required more width than was attainable on the old bridge. The cast-iron 30-in. mains were left undisturbed on this bridge as far as possible. But it was thought advisable to protect the steel pipes to retard cooling, in case the flow of water in either pipe should drop to a very low rate during severe weather. For this purpose the steel pipe was wrapped with the Voorhees' Patent Insulation, a material already used in several exposed situations at Boston.

The space beneath the steel pipe and under the beams was plastered on expanded metal, and a 1-in. plate was bolted to the top of the beams, leaving only two inches for the asphalt street surface above this plane. The change in the pipe was made by the Boston Water Department, while all other work was done by the New York, New Haven & Hartford R. R. Co. The general arrangement of the new 20-in. steel pipes is shown in the accompanying cut, reproduced from a photograph taken from the point of rise over the lower railway, at one end of the Boston & Albany bridge.

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THE FAILURE AND REPAIR OF THE PIERS OF THE AQUEDUCT BRIDGE, WASHINGTON, D. C.

By L. R. Grabill.*

The Aqueduct Bridge was designed to carry the Chesapeake & Ohio Canal across the Potomac River at Georgetown, D. C. The structure consisted of eight stone piers and two abutments placed about 114 ft. apart, c. to c., supporting a series of wooden arches which carried the canal trunk and a highway bridge. The old bridge had a very picturesque appearance, which was heightened by numerous cascades produced by leaks from the canal.

The masonry of the piers, except the cut-waters, is of the roughest character of uncoursed rubble, the stones being laid with little reference to bed, bond, or size. The cut-waters, or ice-starlings, on the upstream end are formed of large granite stones neatly cut to a conical surface. The piers and abutments were erected under the supervision of Maj. Wm. Turnbull, of the U. S. Corps of Topographical Engineers, and were built by day labor between 1835 and 1840. At that time the work was looked upon as a considerable undertaking, as there was in this country little precedent for pier building under the existing conditions.

In 1887, the aqueduct having been removed, an iron highway bridge was erected on these piers by the United States. This bridge consisted of nine Pratt truss deck spans, each 114 ft. long, one trestle, and one through span. The depth to bedrock at the sites of the several piers varies from 20 ft. to 35 ft. below low-water level, the datum employed. When the piers were built the rock was covered by a deposit of sand and mud from 15 to 18 ft. thick. The contraction of the area of the flood cross-section of the stream caused by the piers and abutments and by an embankment at the south end of the bridge produced, at the time of freshets, currents of such increased velocity that the bedrock between the piers has been laid almost entirely bare, practically the last of the deposit having been removed by the great freshet of 1889, the highest of record.

The piers were built within cofferdams, consisting of a double row of sheet piles, the space between the rows being filled with clay puddling. These cofferdams were braced on the interior by timbers 16 ins. square extending across the inclosed space. The lower courses of these braces were not removed, at least in a part of the piers, but the masonry was built up around them and they were sawed off and left in the piers. [illegible] records of the work, as well as the subsequent examination, show that the masonry was [illegible] in all cases carried to the bedrock, but on account of leaks in the cofferdam the excavation of the loose material was not completed, so that in some cases several feet of sand and gravel remained under the lower courses of masonry. It was probably assumed that the scouring action would never reach such a depth as to expose this stratum to erosion; but when this occurred the inevitable result was the undermining of the piers to a greater or less extent, depending upon the stratum underlying the footing.

This result was first observed just after the flood of 1889, at which time Pier No. 1 was [illegible]termined and was found to be moving. Mr. C. B. Hunt, M. Am. Soc. C. E., at that time in charge of the bridge for the District of Columbia, stated that an investigation by a diver "revealed the existence of a scoured cavity under the north edge of the foundation, 4 ft. high at the lip of the masonry, and running back 6 ft. under the pier. It extended the full length of the pier, 66 ft., and across the upstream end, 22 ft. The bottom of the cavity was solid rock for the upstream third of its length, and a sandy silt for the remaining two-thirds."

The result was that the pier was thrown 4 ins. out of plumb, leaning toward the channel, carrying the fixed end of one span with it, until the anchor bolts were cut. The cavity was filled as soon as possible, under Mr. Hunt's direction, with Portland cement concrete, partly loose and partly laid in bags, by divers; the concrete being afterward thoroughly protected by rip-rap. This arrested the motion, and saved the pier, which was still in stable equilibrium. An interesting account of this was given by Mr. Hunt in the "Proceedings of the Engineer's Club of Philadelphia" for December, 1889.

Nearly all of the other piers were more or less damaged by the same flood, on account of similar faulty construction, though fortunately no others were injured so seriously as Pier No. 1. Cavities were noted in piers No. 3 and No. 4; and later a crack was observed extending across Pier No. 4 near its center, which showed from the coping to the water line. The precaution was then taken of

Fig. 1.—View Showing Method of Supporting Spans During Repairs to Pier 4, Washington Aqueduct Bridge.

attaching the ends of the spans resting on this pier to a heavy girder placed longitudinally along the pier and resting upon a bearing of masonry built up on the sound end of the structure. An iron band, tightened by means of turnbuckles, was also placed around the pier at this time.

Early in 1893 the Secretary of War was directed by resolution of the U. S. Senate to have an examination made of the condition of the piers. This developed the fact that dangerous conditions existed in the masonry of Piers Nos. 3, 4 and 6.

*55 Quincy St., Washington, D. C.

and smaller cavities in the remaining piers. The damage to Pier No. 4 was considered too serious to be repaired except by the use of a cofferdam. A contract was made with Shailer, Schniglaw & Co., of Chicago, for repairing the defects. All of the piers except No. 4 were to be repaired with Portland cement concrete in bags, laid under water by a diver; No. 4 was to be surrounded by a cofferdam and repaired with first-class stone masonry, and the ends of the spans resting on this pier were to be supported upon falsework during the process of repair, as a precautionary measure.

This work was done in 1894-5 under the direction of Maj. Chas. E. L. B. Davis, Corps of Engineers, U. S. A., with Mr. John B. Duncklee, Mem. Am. Soc. C. E., as principal Assistant Engineer, and the writer as Assistant Engineer and Inspector upon the work.

The method of repairing the smaller cavities was as follows: The concrete used was made of one part Portland cement, one part sand, one part 1-in. broken stone, and two parts 2-in. broken stone. It was mixed on a lighter at the work, made only slightly moist, and shoveled into small burlap bags. About ⅓ cu. ft., or half enough concrete to fill a bag, was placed in each. The bags were securely sewed and lowered to a diver, who laid them, first clearing the bottom so as to give them a solid bed. When built into the pier the bags were flattened out and bonded with each other as stones would be. Experiments with bags so placed under water showed that at the end of 30 days the concrete had well set and the bags were so firmly united through the pores that it was difficult to separate them.

The last or upper course of bags was forced into place as tightly as possible. After all of the cavities were filled, rip-rap stone was thrown around the piers to protect the repaired parts, an amount of 2,050 cu. yds. being thus placed.

Some of the cavities filled were quite large. Pier No. 1 was found to be in the same condition as when repaired in 1889, being out of plumb something over 1 ft. in its total height, but not having moved since its repair. It required no further work. At Pier No. 3 so large a cavity was found that it was necessary to shore up the overhanging masonry to make it safe for the diver to go under to lay the bags, the opening being from 3 to 10 ft. high, 6 ft. or more deep into the pier, and extending entirely around the west end. At Pier No. 6 also the amount of work required was quite large. At Pier No. 8 one of the cross timbers of the cofferdam, 27 ft. long and 16 ins. square, which was originally left in the pier, had been nearly freed by the erosion and was cut off and removed by the diver. It was perfectly sound. The amount of concrete placed in each of the piers was as follows:

Pier No. 2....	18.9 cu. yds.	Pier No. 7....	19.6 cu. yds.
" " 3....	89.1 " "	" " 8....	5.7 " "
" " 5....	3.6 " "		
" " 6....	57.7 " "	Total.....	194.6 " "

The contract price for concrete in place was $25 per cu. yd.

In order to determine minutely the shape of the surface of the river bed at Pier No. 4 an open raft of large size was built of old timbers and so arranged that soundings could be taken at exact intervals of one or two feet as desired. The raft was tightly moored and carefully located with reference to the axis of the bridge and the center line of the pier, in successive positions covering the required area, and soundings were taken, usually at intervals of 2 ft. in each direction, with a graduated rod lowered through the open spaces in the raft at the required points. The rod was of pine at the upper end, which alone was graduated, and had an iron rod ¾-in. in diameter and several feet long fastened in the lower end, the whole having a length of about 36 ft. By this means a very accurate survey of the bottom was obtained. This showed the river bed on each side of the pier to be bare, solid rock, quite irregular, full of pot holes, lumps, and projections of varying sizes. At the lower end of the pier there was still a mass of the clay which had formed the filling of the original cofferdam; while at the upper end there was from 5 to 10 ft. of the original deposit of mud and sand overlying the rock. The depth to the bedrock varied from about 20 ft. below low water at the east end to 31 ft. at the west, or upper end.

The original dimensions of Pier No. 4 were approximately as follows: length of base 66 ft., including cut-water; length of top, under coping, 42 ft.; width of base at footings, 25 ft.; width of top under coping, 7½ ft.; batter of sides and ends down to footing courses, 1 in. to 1 ft.; depth of foundation below water level, 20 to 24 ft., except at the extreme west end, where it is 31 ft.; elevation of coping above low tide, 30 ft.; making the total height about 61 ft. In order entirely to clear the footing courses, which were very rough and irregular, and also to give working room, it was necessary to make the cofferdam 34 × 84 ft. on the inside. As there was no material to hold piles for the greater part of the distance around the pier, a cribdam built of Georgia pine timber was resorted to. Eight separate open-work cribs were first constructed, each 18 ft. wide and from 34 to 40 ft. long. These were built on shore and the bottoms were carefully worked to fit soundings taken by the contractor. When these were towed into place and moored in position, they were connected by succeeding courses of long timber so as to form a continuous open-work crib 18 ft. wide, surrounding the pier, and having an outer periphery of about 380 ft. There were three lines of longitudinal timbers, with cross timbers at intervals of about 10 ft., thus forming pockets about 9 × 10 ft. Sufficient of these pockets were floored to carry somewhat more than enough stone to sink the crib, it being desired to avoid the cost of removing an excessive amount of stone at the completion of the repairs. The size of timbers used in construction were mainly 12 × 12 ins., 10 × 12 ins., and 10 × 10 ins. in lengths up to 40 ft.

No effort was made to remove the sand and mud which covered the rock at the west end to the depth of 5 to 10 ft., but the cribs were shaped with the intention of resting upon this or sinking into it slightly.

The cribs were built to a height of about 6 ft. above low tide, after which they were covered on the outside by a course of Wakefield triple-lap sheet piling. These were made of three thicknesses of Georgia pine plank bolted together so as to form a tongue of the inner plank projecting about 3½ ins., with a corresponding groove. They were in lengths of 26 ft. to 36 ft. and for the greater part required no driving except what was necessary to overcome the friction in the grooves, being lowered into place or tapped lightly until they brought up on the rock. They were fastened below water by a diver, who also looked after the fitting at the bottom. At the east end, where the mass of clay was left from the old dam, they were not driven to bedrock, as the driving there was very hard; but at the west end they were driven through the sand and mud above the site of the piers to solid rock, thus extending from 4 to 8 ft. below the lower timbers of the crib, which rested on the stratum of sand and mud.

The area of the surface of the dam exposed to water pressure was about 9,000 sq. ft. at low tide and about 1,200 sq. ft, more at normal high tide of 3 ft. rise.

After the completion of the crib four trestle towers were constructed upon it, one under each truss resting on the pier, and extending up to the level of the lower chords of the bridge trusses. Each tower carried two corbels, which supported the ends of heavy timber A-trusses in pairs, one on each side of the adjacent bridge trusses. From two oak blocks resting across the apex of each pair of A-trusses, four 1¼-in. steel stirrup rods, with upset screw ends, were suspended by nuts resting on iron-bearing plates. These stirrup rods supported stirrups extending under the end pins of the bridge trusses. By means of the nuts and screws the entire weight of the spans was taken off of the pier and brought upon the towers on the crib, Fig. 1. The crib was carefully shored by the diver below these towers, but considerable settlement occurred when the weight was placed upon it.

As a further precaution the overhanging masonry of the cut-water was shored up from the bottom with heavy timbers before any pumping was done.

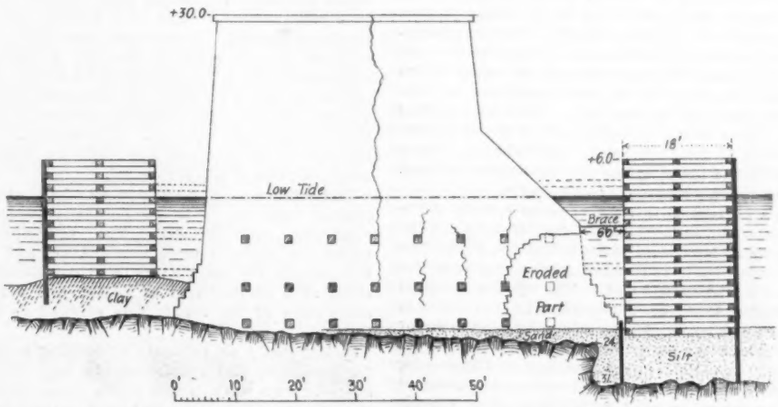

FIG. 2.—SECTION OF PIER NO. 4, WASHINGTON AQUEDUCT BRIDGE, ON CENTER LINE, ACROSS THE ENDS OF THE COFFERDAM, SHOWING EROSION AND APPROXIMATE POSITIONS OF CRACKS IN THE MASONRY.

From 6 to 8 ft. in depth of gravelly clay was placed around the foot of the sheet piles outside of the dam.

Temporary horizontal shores were placed by the diver from the crib to the pier at short intervals, but not until it had been demonstrated that such bracing could not be safely put in as the dam was slowly pumped out. This was shown, when after pumping out about 12 ft. of water and preparation was being made to put in the third set of shores from the top, the crib suddenly yielded to the pressure of the north side, so that the top of the dam was forced toward the pier and the crib was thrown 1½ ft. out of plumb on that side. The dam, of course, quickly filled, and leaks were caused which required several days to close. The bracing of the upstream end of the dam, next to the eroded part, was difficult, but the crib was finally trussed so as to render it very stiff at this end.

Pumping was at first begun with an 8-in. centrifugal pump, but this was found inadequate, and later a 10-in. duplex Worthington pump and a 40-HP. boiler were added to the plant. Several leaks were sprung and were patiently repaired during the operation of pumping out the dam. About 18 days after pumping had begun a depth of 19½ ft. below low tide had been reached, just exposing the shallower part of the bottom. Quoting from the report of Maj. Davis:

> On the same day a serious leak occurred at the southwest corner of the dam, which was checked somewhat, but not stopped. The pumping was continued and the same level was preserved through two high tides, each of which increased the head 3 ft. (the leak meanwhile gradually increasing), until 2 p. m. on April 24, when the sheet piling broke and the water burst through the dam with great violence, the sudden inrush of water being so great as to completely fill the dam in ten minutes. So great was the force of the water that the silt 10 ft. in depth was washed away from the sheet piling on the inside and churned into black foam as it rose to the surface. The break occurred at the bent at the extreme southwest corner of the dam. This bent is 9 ft. long and a number of sheet-piles along its face were broken and forced in by the pressure of the water, due to the head of 19½ ft. The sheet piling here had been carelessly driven, the joints being open and the

piles somewhat split. The contractors did not sink the crib through the bed of silt to the solid rock, but allowed it to rest in the upper part of the silt stratum about 6 or 8 ft. above the rock. Outside of the crib the triple sheet-piling were driven to the rock, but under the conditions noted yielded under the pressure and the dam failed.

The immediate cause of this break was that small leaks through the cracks between the piles had loosened and washed away the silt immediately behind the piles, thus leaving 6 to 8 ft. of the lower end of the piles without horizontal support. Under the heavy pressure the piles first bent inward and finally broke. This break was repaired by driving another row of sheet piles outside of the broken ones, and filling against them on the crib sides with stone, for a depth of several feet. The clay puddling on the outside was replaced. The dam was finally pumped out about two months after the pumping began, and was then easily kept dry, the leakage amounting to about 600 gallons per minute.

The river bed was exceedingly rough. The eroded cavity, Fig. 2, was found to extend entirely across the pier, about 25 ft. at the bottom. It was 19 ft. from the under side of the overhanging masonry to the bedrock directly below; and the depth into the pier, in the direction of its length, was about 12 ft., measured from the upstream edge of the overhang. Perhaps one-half of the fallen stone, including one of the cut granite stones of the ice breaker, was found in a heap at the foot of the pier, but the remainder had been carried entirely away, probably by ice.

Three horizontal courses of cross braces of the original cofferdam, 21 in number, 16 × 16 ins. by about 25 ft. long were imbedded in the pier. The spacing indicates that three others had been imbedded in the eroded end. The erosion extended lengthwise back approximately to the timbers farthest upstream. From almost every timber of the seven in the upper course a crack was found to extend upward into the masonry, and the crack originally noticed led to one of the vertical rows of these timbers, each of which formed a partial "straight joint" through the stone work.

At the west end of the pier where the bedrock was lowest, the lower-footing course had not reached it, but had apparently been continued nearly on a level with the bedrock at the east end, which was from 3 to 4 ft. above the level of that at the west end. In addition, just under the upstream end of the original footing, there was a sudden vertical drop in the bedrock of about 6 ft. from 25 ft. below datum to 31 ft., as shown in the sketch, Fig. 2, given herewith. This drop was evidently unknown to the original builders, who had constructed the upper end of the foundation at this point over about 10 ft. of sand and silt, while the entire upstream half of the footing course had from 1 to 4 ft. of sand below it, diminishing in thickness toward the lower end with the rise of the rock.

As soon as the whirling, scouring, digging freshet current had reached the level of the bottom of the footings in the process of erosion, the undermining of the pier was begun. This would have occurred with any class of masonry, but that which composed the lower part of the pier was such as to facilitate the rapid work of destruction; for it was little more than large rip-rap apparently tumbled into place, without regard to size, shape, bed, or bond. Openings into which a rod could be pushed several feet were numerous. The work at this level was probably very hastily done on account of the leaky condition of the first dam, which the reports of the work show to have caused much trouble. The poor quality of the stone work was to some extent made up for by the wide spread of the footings which fortunately protected the pier considerably.

The limbs of trees were found under the loose masonry removed to be rebuilt. As far as the work of removal extended, a layer of sand and silt was found which reached under the pier. One tree trunk extended so far under the undamaged part of the pier that it had to be cut off, leaving the top part. Fully 12 ft. in height of the work was of such masonry. Above this it was built with more care, but was still very poor.

Under these conditions it was considered best to rebuild the pier while the cofferdam was in place, but as the appropriation at hand had only been made with the object of the repair of the eroded portion, and was not sufficient to rebuild it, it was decided to proceed with the original project, but to leave the cofferdam in place for reconstructing the pier at a later period.

It was necessary to build a small interior cofferdam around the upper end, at the 6-ft. drop in the bedrock before mentioned, before the excavation at this point could proceed to bedrock, 31 ft. below low water. When this had been done, the bedrock was thoroughly cleaned and found to be level at this point, and the inner dam was then entirely filled with Portland concrete to the elevation of 24 ft. The projections and inequalities above this elevation were dressed down to the same reference, affording a level surface upon which to start the masonry. The new work was built of Potomac River gneiss, in first-class coarsed rubble, the courses varying in thickness from 1 to 2 ft. The plan of the end as replaced was in the shape of a semi-octagon. A part of each of three courses of the granite ice-starling which overhung the cavity was removed to facilitate construction. The new portion was built firmly to the old, into which it was bonded. The cavities on both sides of the pier, where it was undermined for a large part of its length and in places for 3 or 4 ft. in depth, were also filled with rubble masonry. The removed courses of the cut-water were then replaced. The amount of new masonry built in place was 208.9 cu. yds., at a contract price of $30 per cu. yd.

The entire cost of repairs to all of the piers, including payment for and subsequent purchase of cofferdam was $46,379. The cofferdam, for which the contract price was $24,000, and which belonged to the contractors, was purchased from them at a further cost of $3,000, and after the completion of the repair was allowed to fill by leakage.

Subsequently an estimate amounting to $65,000 for removing and rebuilding the pier was submitted. This work is now under way. A part of the pier has been removed, and pumping is in progress at the dam. The arrangement for supporting the spans is the same as that described above, and as shown in the view, Fig. 1.

CONCRETE PIER SUPERSTRUCTURE FOR THE NEW SHIP CANAL ENTRANCE TO DULUTH HARBOR, MINN.

(With two-page plate.)

A full description of the new ship canal entrance to the harbor of Duluth, Minn., was published in Engineering News of July 28, 1898. As described there the new entrance consists of a dredged channel between two substantially parallel piers consisting of a concrete superstructure founded upon timber cribs resting on a prepared foundation bed on the sand bottom of the lake. At the time that this description was published tentative designs only had been adopted for the concrete pier superstructure, and the final designs, while conforming closely in their sectional profile and general structural arrangement to the preliminary designs, were considerably different in other respects. These revised designs are shown by Fig. 1, which gives cross sections of the main pier at two points where the exterior construction is different and also one through the enlarged end of the pier or the pier head.

The general construction is as follows: At the two bottom longitudinal edges of the concrete superstructure there are laid two rows of concrete footing blocks. The bottoms of these blocks are stepped into the crib timbering so as to prevent any possibility of movement outward from the center of the pier. The top surfaces of the blocks are also given a batter upward from the inner edges outward. Between these two rows of footing blocks there is a filling of rubble and gravel, the top of which comes 6 ins. below the top inner edges of the concrete footing blocks. The result of this construction is a trough-shaped top surface, with steps at the two lines of junction between the footing courses and the rubble and gravel filling, on which rests the upper monolith of concrete. This monolith of concrete is lightened by interior galleries arranged as shown by the sections in Fig. 1. Other details of the construction are shown by the drawings which we take from the report of Maj. Clinton B. Sears, U. S. Engineer Corps, contained in the report of the Chief of Engineers, U. S. Army, for 1899. From this same document we abstract the following interesting details concerning the manufacture of the large concrete footing blocks, and regarding the other concrete work so far as it had progressed up to June 30, 1899.

The entire concrete work of the pier superstructure was placed under the direction of Mr. Clarence Coleman, Assistant Engineer. Actual work was begun on June 21, 1898, by King & Steele, of Duluth, Minn., the contractors for the concrete footing blocks for the south pier superstructure. Their work for the season of 1898 was stopped on Nov. 7, at which time 502 blocks, containing 1,691.568 cu. yds. of concrete, had been completed, piled and accepted by the engineers. The concrete composing these blocks consisted of trap pebbles from 2½ ins. to ¼-in. in diameter, Portland cement, and sand, 100% of which passed a No. 4 sieve, and not more than 50% of which passed a No. 30 sieve. The pebbles were for the most part indurated sandstone, trap and quartz. The sand was pumped from the lake bottom and was composed principally of particles of silica and trap. Six different brands of Portland cement were employed, five being American and one German.

The mixing was done on movable platforms, which were always placed alongside the molds to be filled. Mixing on the molding platform was prohibited to insure the preservation of a smooth molding surface for the base of the blocks. Full details of the mold construction are shown by the drawings comprised in Fig. 2. The pebbles were always thoroughly washed, and while moist from the washing were transported in measuring carts of ½-cu. yd. capacity each to the mixing platform, dumped and spread to an even thickness of 6 ins. The sand was spread on the pebbles in a like manner, and the cement, after being weighed, was spread on top of the sand and pebbles. After a thorough mixing dry, the mixture was again spread out on the platform to an even thickness of 6 ins., and water was added carefully, the mixing proceeding as the water was being applied and continuing until the mass was in such a condition of plasticity that five or six sharp blows from the back of a shovel would produce a glistening appearance upon the surface of the concrete so treated. The concrete was then immediately shoveled into the molds, and after being spread in layers not more than 5 ins. deep was thoroughly rammed with iron rammers having a face area of 25 sq. ins., and weighing 40 lbs. each. Special flat rammers of oak shod with ½-in. steel were used for compacting around the sides of the mold. No attempt was made to provide special material for the surface of the block, a smooth and handsome appearance being accomplished by thorough ramming of the concrete. The batches as mixed contained each 1 cu. yd. of pebbles, ½-cu. yd of sand and 432 lbs. of cement. As indicated above, the pebbles and sand were accurately measured and the cement was always weighed.

During the work careful computations were made by Mr. Coleman to determine the voids in the aggregates and the percentage of shrinkage due to consolidation, and from them we abstract the following figures: As determined from a number of averages the voids in the pebbles used amounted to 38.592%, so that an excess of 11.4% of sand was used over the amount required just to fill the voids. The whole volume of aggregates as mixed was thus increased by that percentage. Then, considering this increase of volume resulting from the excess of sand used, the amount of cement in 1 cu. yd. of aggregates would be represented by 432 lbs. less 11.4%, or 432 — 49.248 = 382.752 lbs. The total number of batches mixed and used in the construction of the 502 footing blocks was 1,529.73, and each batch, as stated above, consisted of 27 cu. ft. of pebbles, 13.5 cu. ft. of sand and 432 lbs. of cement. The shrinkage of the entire volume of the dry aggregates, due to all causes, as shown by the concrete, measured in place would then be as follows: Volume of pebbles, 1,529.73 cu. yds., plus volume of sand; 764.865 cu. yds., plus volume of cement taken at 85 lbs. per cu. ft.; 331.55 cu. yds., or a total volume of 2,626.145 cu. yds., minus volume of concrete measured in place, 1,691.568 cu. yds., equals

934.577 cu. yds., or a total shrinkage of 35.58%. It is stated above that the sand used exceeded in volume the actual voids in the pebbles by 11.408%. Then the volume of concrete mixed would be represented in cu. yds. by the total number of batches plus 11.408%, or 1,529.73 + 174.511 = 1,704.241 cu. yds. The total cubic yards of concrete as measured in the blocks was 1,691.568. Thus the shrinkage due to consolidation is represented by 1,704.241 — 1,691.568 = 12.673 cu. yds., or 0.743 of 1%. From a number of tests made to determine the voids in the concrete as molded the average results showed 1.63% for absorption.

Further computations were made by Mr. Coleman to show the relative cost of a concrete composed of pebbles and waterworn sand and of one composed of crushed stone and crushed sand. In both cases the sand was assumed to fill the ascertained voids in the stone or pebbles, and the cement was assumed to fill the ascertained voids in the sand, or, in other words, the voids in the concrete were to be, theoretically, zero. In the actual aggregates selected for the comparison the voids were as follows:

Material.	Per cent. of voids.
Pebbles	36.555
Crushed stone	47.555
Waterworn sand	34.000
Crushed sand	53.000

According to these figures the amount of cement required for 1 cu. yd. of crushed stone and sand concrete was 598.05 lbs., and the amount required for 1 cu. yd. of pebbles and waterworn sand concrete was 335.61 lbs. The saving in cement for the pebble and waterworn sand concrete was thus 262.44 lbs. per cu. yd., or at a price of $2.19 per barrel of 380 lbs. of cement, a saving of $1.512 per cu. yd. of concrete. This last amount is the theoretical saving per cu. yd. of the gravel concrete in cost. The actual saving in the work as carried out was less, since the amount of cement actually used for each cubic yard was 382.752 lbs., instead of the above 335.61 lbs. theoretically required just to fill the voids in the sand. Taking the figures of the amount of cement actually used, the saving per cubic yard of the gravel concrete actually employed over the crushed stone concrete described above, amounted to $1.241 per cu. yd., or of $24,671.08 for the total 19,880 cu. yds. of concrete employed in constructing the piers. These figures Mr. Coleman mentions do not take into account the difference in the cost of the natural pebbles and sand and the crushed stone and sand.

So far the description of the concrete making has been confined to the work done on the footing blocks for the south pier during the season of 1898. Work for the season of 1899 was begun on April 24 by Mr. Charles Stone, of St. Paul, Minn., the contractor for setting the footing blocks for the south pier, making and setting the footing blocks for the north pier, and building the concrete monolith for both piers. From information received from Mr. Clarence Coleman, Assistant Engineer, through Maj. Clinton B. Sears, U. S. Engineer in Charge, we are able to present to our readers a number of illustrations and a general description of the plant and work of this contractor as they had been carried out up to the middle of April, 1900. Briefly described, the plant consisted mainly of a large steam traveler for setting the monolithic blocks and handling the block molds, a steam traveler for piling and setting the footing blocks, a concrete mixing plant, a steam power gravel washing and screening plant, and tracks, cars, etc., for handling concrete and other materials.

During the season of 1899 and the winter of 1900 the chief work of the contractor consisted in completing the remainder of the 1,417 footing blocks and in installing his plant and preparing for the work of setting the footing blocks and building the concrete superstructure. The method of mixing the concrete and molding the footing blocks was the same essentially as that already described as being used during 1898. Fig. 3 shows the mixing and molding work in progress. The gravel washing and screening plant is shown by Fig. 4. As the footing blocks were completed and approved by the engineer they were piled up in the storage yard ready for setting.

The work of setting the footing blocks in place was commenced on March 6, 1900, and up to the middle of April about 530 had been placed. This work has been prosecuted at times with the temperature considerably below zero, Fahrenheit, the men working in the water being protected with waist rubber boots and rubber mittens and clad in very heavy Mackinaws to enable them to withstand the cold. The principal difficulty encountered was due to the very low temperature of the blocks, which caused ice to form rapidly on those surfaces immersed in water. This difficulty was overcome by setting the blocks on the cribs in the water for a few hours before setting in their final places. During this time they absorbed sufficient heat from the water to prevent congelation on the surfaces immersed. It was found necessary, however, that they should be supported on blocking several inches above the decking of the cribs while this thawing-out process was in progress, otherwise they would freeze fast to the deck, requiring the united energy of the steam derrick, powerful jacks, and wedges to remove them.

The traveler used in setting the blocks was constructed on the ground, and adapted to the work in hand. It consisted essentially of a steam derrick with a revolving platform elevated above the trestle track sufficiently to allow cars loaded with concrete to pass under it. The boom was sufficiently long to set the blocks on both sides of the crib. The blocks were loaded on cars at the storage yard by means of a gallows frame with a differential block of 16 tons capacity, the gallows frame being mounted on castors to facilitate their easy handling. The transportation of the blocks to their destination was effected by means of a tail end wire rope haulage plant. After the footing blocks had been set in place, the vertical grout holes formed by the juxtaposition of the blocks were filled with a cement grout composed of 1 part of cement to 2½ parts of sand. This grout was introduced into the holes by placing a sleeve of thin muslin made of a slightly greater diameter than the hole to be filled and then pouring the grout until the hole was completely filled. This part of the work was done with the temperature of the air above 32° F.

Figs. 5 to 10 illustrate the work of setting the concrete footing blocks. Fig. 5 shows the gallows frame used for loading the concrete blocks on to cars at the storage yards, and Fig. 6 shows these same cars on their route to the work from the storage yard. The derrick used for setting the footing blocks is shown by Fig. 7. Fig. 8 is a detail view showing the placing of a block with the men working in the water up to their hips. Mention has already been made of the method of warming the blocks by immersing them in the water previous to setting. Fig. 9 is a view showing two of the workmen adopting the same method to keep their feet warm while waiting for the derrick to bring a block. When this view was taken the temperature of the atmosphere was — 10° F. If the cheerful countenances of the two gentlemen who are using this unusual foot warmer are any indication of its efficacy for the purpose it would seem to have been an excellent device. In Fig. 10 we have a view of the two lines of footing blocks in place and ready, except for the filling of the occasional gaps, for the placing of the rubble and gravel filling and the concrete superstructure, Fig. 1.

The rubble filling and concrete work above the footing blocks has not yet been begun, but its character and the general methods of carrying it out are stipulated in the specifications. The rubble filling, 2 ft. thick over the deck of the cribs between the two rows of footing blocks, will consist of broken stones of igneous rock, such as granite or trap weighing at least 170 lbs. per cu. ft. This rock is to be broken into pieces not more than 8 ins., nor less than 3 ins. in their greatest diameters and deposited in layers 8 ins. deep. After each layer is deposited, a sufficient amount of pebbles of the character and size previously described as being employed in making the concrete footing blocks is to be spread on the rubble to fill the voids in it. This filling is to be kept completed at least 100 ft. ahead of the concrete work of the superstructure.

The standard construction of the pier superstructure is in blocks 10 ft. long longitudinally of the pier and with vertical and transverse dimensions corresponding exactly to the sectional form of the completed work shown by Fig. 1. Standard molds will be employed for making these blocks, inside of which the centers for forming the interior galleries will be placed in the proper position. For forming the pier heads, stairways, curves, etc., special molds will, of course, be provided. These molds are to be made of sound white pine frames and lagging tied strongly together by iron rods and lined with No. 8 gage steel plates fastened closely and smoothly to the lagging by screws, except the pier head and other special molds where no steel lining is to be employed, but which are to have the plank lagging carefully dressed so as to give the concrete a smooth surface finish.

The concrete used in the superstructure blocks is to consist of Portland cement, sand and pebbles of the quality employed in making the footing blocks and previously described. These materials are to be mixed in the proportion of 1 cu. ft. of pebbles, ½ cu. ft. of sand and 16 lbs. of cement. Before depositing any concrete in the molds the top of the rubble filling between the footing blocks is to be carpeted with 8-oz. burlap sewed together with twine. All concrete is to be transported from the mixer and deposited in the molds as soon as possible and in no case must more than 30 mins. elapse from the time the water is added in mixing until the concrete is deposited in the molds. As soon as the concrete is deposited in the molds it is to be spread in layers not more than 4 ins. thick and each layer is to be rammed with iron rammers having faces 5 × 5 ins. and weighing not less than 40 lbs. No pebbles more than 1½ ins. in diameter are to be placed within 3 ins. of any face of a block, which will form an exterior surface when the block is completed, the finer material being selected for molding all outside surfaces. For ramming the concrete near the sides of the molds special oak rammers having ½ × 5-in. faces are to be employed. The molds will be removed generally about 24 hrs. after the completion of the blocks, after which the surfaces of the blocks are to be kept shaded by burlap coverings and thoroughly wetted for at least ten days.

Up to the middle of April none of the concrete superstructure blocks had been built, but the plant was being rapidly installed for this portion of the work. From information received from Mr. Coleman through Maj. Sears, we are able to give a brief description of this plant and of the proposed methods of operation. A haulage plant of the endless rope system is being built for handling the concrete for the large monolithic blocks, and a concrete mixer which is being built will be given a trial when the work begins. This machine is shown by Figs. 11 and 12 and consists essentially of a rotating horizontal disk with a rim about 18 ins. high around its perimeter. Plows are so arranged on fixed arms above this disk that the concrete materials being dumped on the rotating horizontal platform or disk, will be constantly turned by the plows. The plows are so placed with regard to their several tracks that a furrow opened by one plow is immediately filled by the succeeding plow and thus the materials are constantly thrown from one side to the other and at the same time carried around over the whole revolving platform and very intimately mixed as a whole. The greatest advantage hoped for from this machine is in having the entire batch visible while being mixed and thus enabling the inspector to determine the proper consistency of the concrete. After the concrete has been mixed to meet the requirements of the specifications, it is discharged directly into the concrete cars by means of slots in the bottom of the rotating disk, a scraper flange being lowered by means of a lever to effect the thorough discharge and cleaning of the machine as each batch is discharged. The machine is intended to perform all of the operations of mixing without stopping; the materials being discharged from an upper platform through their appropriate chutes into the machine and the batch being discharged through the three slots in the horizontal rotating disc without stopping the machine. The diameter of the rotating circular disk will be about 11.5 ft. and the speed about 9½ revolutions per minute. It is proposed

to mix 1 cu. yd. at one mixing, and as fast as mixed it will be discharged into buckets on cars, each car carrying two buckets.

These cars will be run out to the molds in trains of four, carrying 8 cu. yds. of concrete. On arriving at the molds the buckets will be lifted from the cars by means of a small traveling derrick, set inside the molds, their bottoms tripped by a device for that purpose, and the concrete deposited for ramming in place. The molds will be moved and set up with a floating derrick so as not to interfere with the operations on the trestle, the floating derrick always working upon the opposite side of the cribs to that upon which the trestle is located.

During the construction of the concrete footing blocks, samples of the concrete were taken from the mixing platform as mixed, from which briquettes were made. These briquettes were treated as nearly as possible to conform to the treatment of the concrete in the footing blocks. The results obtained were highly satisfactory. The accompanying table is a sample of some of these results as obtained with an American Portland cement. In making these briquettes it was necessary to remorve pebbles more than ¾-in. in their greatest diameter to permit the concrete to be compacted into the briquette molds. It was found on breaking those briquettes that at 28 days and thereafter, pebbles imbedded in the mortar at the breaking section, were almost invariably broken. It will be seen from the table that the mean tensile strength of five briquettes, one year old, was 643 lbs. Assuming a coefficient of 7 for strength in compression would give 4,501 lbs. per sq. in., or 324 tons per sq. ft., as the ultimate resistance to destructive stress in compression.

Table Showing Tensile Strength of Concrete in Briquettes at Different Ages.

Age.	Lbs. per sq in.
7 days	222.4
28 "	388.4
6 months	414.6
1 year	643.0

NEW JERSEY FORESTS AND THEIR RELATION TO WATER SUPPLY.*

By C. C. Vermeule.†

The condition of the forests of New Jersey is interesting, because of their proximity to great cities, and the fact that the State itself supports a dense population. The northern portion has a population of 1,300,000 people, or 450 per square mile, yet it still preserves 575,000 acres of forest land. The whole State his in round numbers 2,000,000 acres of forest, which is almost exactly equal to the area of improved farm land. Of this 800,000 acres is deciduous, and 1,200,000 acres coniferous forest.

A study of these forests by the Geological Survey of New Jersey really began as far back as 1878, and during the succeeding ten years the entire area of forest lands was mapped in connection with a topographic survey. When the Survey took up the question of water supply, with a view to an extended report thereon, in 1890, the relation of the forest to this problem was incidentally studied, but much more recently the Survey has been charged with an examination and report upon the forests themselves, and this work is now far advanced.

The larger part of the forest is in three tracts, of which 58,000 acres is on the rugged Kittatinny Mountain; 211,000 acres in the Northeastern Highlands, and a smaller body of 11,000 acres almost at the doors of New York, on the trap of Palisades Mountain. This last area is chiefly remarkable, because of its close proximity to the dense population of the metropolitain district about New York. It contains much really fine timber, and all interested in the cause of forestry must earnestly desire its preservation.

A fortunate circumstafice in the distribution of this forest cover, is its prevalence on the slopes, all of which are well wooded. However, this is only another way of stating the simple fact that the forest cover only prevails upon lands which are unsuited for agriculture, such as the rather sterile trap ridges, and the thinly soiled slopes of the Highlands and Kittatinny Mountain. So the greater prevalence of forest in the glaciated portion of the State is explained by the fact, that the soil has been stripped from the ridges and the detritus deposited in the valleys in such a way as to render the country unfit for agricultural uses. I use the term forest to include all land devoted to the growing of timber. It ranges from stump and brush land up to timber of large size.

It is important to know the exact relation which our forests bear to the water supply, because of the prominence of the water question in the vicinity of New York. A very large proportion of the population of New Jersey is dependent upon public water-works. The investment in these works is in the aggregate much larger than the value of the entire forest of the State, and the health and prosperity of 1,300,000 people depend upon the maintenance of a wholesome and abundant supply, consequently whatever may be the importance of the forest cause, it is subordinate to this greater interest. These facts have made us extremely conservative in adopting and promulgating certain theories as to the effect of the forest upon the stream flow.

I stated some of the results of our studies at the Springfield meeting of the association in 1895. Briefly, they were to the effect that we had not been able to discover that evaporation is lessened by the presence of forests, but that our studies had led us to conclude that forested water sheds gave a more uniform discharge, and were in other respects more desirable for public water supply. Mr. Geo. W. Rafter took exception to these conclusions in a paper read at your Nashville meeting, in 1897. Comparing a three years' series of observations on the deforested Genessee River, with a six years' series on the Upper Hudson, Mr. Rafter drew the conclusion that the difference in evaporation between a forested and deforested area in the State of New York is 5 or 6 ins. per year. Perhaps an illustration will make clearer to you why I have taken a more conservative position, not only in the interest of water supply, but I believe in the true interest of the cause of forestry itself. You are aware that the great city of New York is at the present time facing the necessity of an increase in its water supply. This supply is drawn from the Croton River, which has 353 sq. miles of catchment, and about 30% of this area is woodland. The engineers of the city have usually estimated that this is capable of supplying 280,000,0000 gallons daily, or say 17 ins. of rainfall upon the catchment. Now if Mr. Rafter's conclusions are correct, an increase in the forest upon the Croton, from 30% to about 80% of the area, will suffice to increase this quantity by about 5½ ins., or 92,000,000 gallons daily, and instead of incurring an immediate large expenditure in extending its water-works, the city could afford to spend $40,000,000, or about $400 per acre, in planting trees upon the catchment, disregarding entirely any revenue which might be derived from the forest. But suppose, on the strength of Mr. Rafter's conclusions, the city should take this step, and it should fail to give the desired increase (as I, in common with most water-works engineers, believe it would), would not the cause of forestry suffer a serious set-back, through a failure which would be so widely advertised and so unfortunate in its results to the city of New York? The crucial test of the faith of those engineers who believe in these conclusions, therefore, will be found in the query, whether they are willing to advise the city of New York to take this step, which will be a wise one if they are correct.

In studying this phase of the forestry question, I have gone over and compared a mass of conflicting data and information. These are by no means all favorable to the conclusion that evaporation from forests is less than evaporation from ordinary farm land or fallow land. Thus in the Strasburger Botany, we find a statement as to the evaporation from an oak tree, from which the conclusion must be drawn that a forest of such trees will require during a growing season from 16 to 19 ins. of rainfall. The conclusions of Burger indicate that a forest which will cut 40 cords of wood per acre, will require 19 ins. of water during the growing season. On the other hand, the experiments of Lawes and Gilbert, Greaves, and Evans and Dickinson in England, show an evaporation from uncropped soil amounting to from 16.9 to 21.2 ins. per annum, and during the growing season from 9.4 to 11.9 ins. only, or about 60% of the above figures for forest. As for farm crops, the interesting experiments of Professor King, at the University of Wisconsin, show, that a crop of clover of two tons to the acre, requires only about 10 ins. of rainfall, and taking the normal field crop, his results indicate that during the growing season Indian corn requires 4.8 ins.; barley, 3.6 ins.; oats, 3.6 ins.; wheat, 4.5 ins., and potatoes about 10 ins.; the average for these field crops being 6 ins., against the 16 to 19 ins. said to be necessary for forests.

A certain class of experiments, which have undoubtedly influenced opinion, are not at all pertinent to this discussion. I refer to those which show that the evaporation from a tank of water or from the soil underneath the tree tops of the forest, is less than in the open country, for we must remember that to the evaporation thus determined we must add a very large quantity of water taken up through the trees and transpired into the atmosphere, and also that portion of the rainfall which is intercepted and absorbed by the leaves, so that it never reaches the earth. I am disposed to attach much weight to the conclusions of Becquerel, a member of the French Academy of Sciences, who devoted most of a long lifetime to those studies, and had all of the European data at his disposal. In a very admirable paper upon forests and their climatic influence, he has pointed out the exact effect of forests upon springs and water courses.* He does not believe they diminish the evaporation of rain wat[er] effect the amount of rain, but points out what we [have] concluded from our own studies, that the flow o[f] springs is better maintained in a forested country—[that] is, the stream flow is more uniform and less fluctu[ating]. Indeed, it is exceedingly difficult, in experiments [on a] small scale, to approximate to the conditions which [pre]vail over an extended tract of country; and for this re[ason] while I have not ignored experiments such as thos[e al]ready quoted, I believe that much more certain [con]clusions may be drawn from a careful study of the [most] and longest series of stream gagings which can be [ob]tained. If such accurate gagings extend through a [con]siderable period of years, so as to show the amount [of] water which runs off from a given area, and we [can] obtain good contemporaneous measurements of the rain[fall] fall upon the same area, the difference between these [two] quantities will usually represent the evaporation. If we can compare such measurements on forested areas, with like measurements from areas under cultivation (the temperature and rainfall being similar on the two streams), we should be able to determine the influence of forests upon evaporation. I have carefully compared and analyzed such data for 34 different catchments, mainly in the New England, Middle and Southern States with some in the West, and some European streams. The amount of forest upon these catchments varies from nearly 90% of the catchments down to practically none. The result of my studies has been to establish what I believe is the true relation of evaporation to the temperature and the rainfall. The influence of these two factors is clearly predominant, and suffices to explain all of the differences of evaporation observed upon the different streams, excepting a small minority of cases in which there are discrepancies not yet explained on any other hypothesis than inaccuracy in the gaging or rainfall. The large number of streams which obey the established laws of variation determined solely by rainfall and temperature, indicates that, at least tentatively, we may conclude that these are the only important factors in determining evaporation. There is absolutely no trace of any effect whatever due to the forests.

This matter of evaporation is of the very first importance in the water supply question, because it affects the amount of water which can be collected from a given gathering ground. It is not usually possible in this vicinity to depend upon collecting much over 14 ins. of the rainfall annually. This is about what we estimate for the Passaic catchment, and if it be true that a difference of 6 ins. is likely to be brought about through a loss of 50% of forest area, then if the 53% of the forest upon the Passaic catchment should disappear, the available supply would be reduced almost one-half. We believe this to be a fallacy, which is dangerous to the water supply question, and also to the forestry cause.

What, then, are the beneficial effects of forests? The data which we have analyzed and studied point strongly to those we have already indicated as the principal ones, viz.: a greater permanence of the springs and the more equable flow of the streams. The forested streams will carry less silt or mud in suspension, and the water will usually be softer. The economic importance of these two points is very great. The condition to be most shunned upon a watershed is barrenness, and this will surely result if the forests are destroyed upon land which is unfit for cultivation. Cultivation preserves the absorbent power of the soil, and to a considerable extent equalizes the run-off and prevents floods, while a stream with a barren catchment is subject to very violent floods and long periods of low water.

From a hygienic standpoint, the best conditions for water supply are probably those in which the hillsides and higher land are in forest, while the valleys near the stream are clear and in grass. Such conditions will produce water freer from organic matter than that which comes from a watershed entirely forested down to the stream. These are just the conditions which we have in the Highlands of New Jersey, and here is where the cities of the State have learned to look for their water supply. The region is well covered with lakes and ponds, three conspicuous ones being the large storage reservoirs which now supply the city of Newark. Others are being completed in the same region for Jersey City, and it is safe to conclude that if a policy of forest reservation is ever adopted in the State of New Jersey, the water supply question will be kept in view. The cause of forestry and that of water supply might both be admirably served by a series of reservations, which would include the gathering grounds utilized by the cities of the State. If this policy is adopted with accurate knowledge of the nature of the benefits to be expected we feel satisfied that it will prove permanent and satisfactory.

*Abstract of a paper read before the meeting of the American Forestry Association, at New York, June 25 and 26, 1900.

†Consulting Engineer, 203 Broadway, New York City.

*See Atlas Météorologique de l'Observatoire Imperial, 1867, also a translation in Report Upon Forestry, by F. B. Hough, U. S. Department of Agriculture, 1877.

A $16,000,000 ISSUE of public improvement bonds at New Orleans is now being advertised, bids to be received until Dec. 15, 1900. The proceeds will be used to pay for the construction of water, sewerage and drainage works, but contracts cannot be let until the money is in hand. The drainage work was begun in 1897. The central section, between pumping stations Nos. 2 and 7, lacks only ¼ mile of open canal of being completed, and it is expected that it will be finished and in operation by Oct. 15. The contracts let in July, 1899, are well under way.

A NEW TRANSMISSION DYNAMOMETER.*

By W. Elwell Goldsborough.†

The dynamometer shown in Fig. 1 is designed especially for testing electric motors of from 5 to 25-HP. capacity, and can only be used by directly connecting it between the driving element, the motor to be tested and the driven element, a dynamo, adjusted to absorb the power developed. It consists of a shaft, shown in Fig. 2, which is made in two parts. These are kept in line by having a projection of the left-hand section turned down to fit exactly a concentric hole bored in the right-hand section of the shaft. The joint presents a sufficient bearing surface to enable the instrument to stand quite severe lateral strains, although it is not sufficient to admit of the dynamometer being used to transmit power through the medium of belt-driven and driving pulleys attached to the outer ends of the shaft. For the dynamometer to be available for this class of work, the two sections of the shaft should be made in the form of quills to fit a second shaft extending completely through both sections.

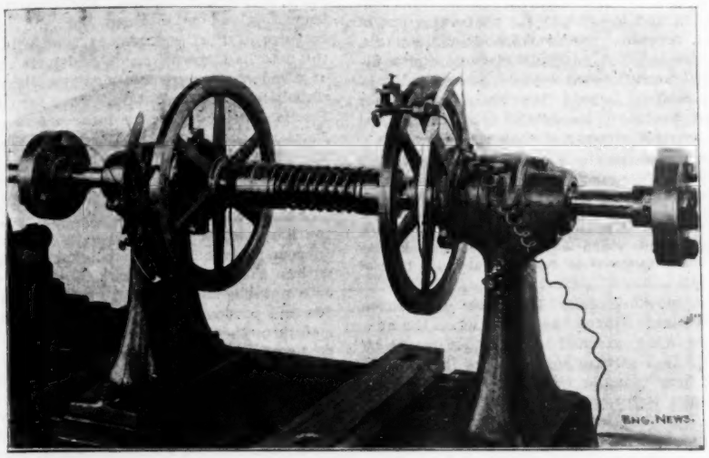

FIG. 1.—A NEW TRANSMISSION DYNAMOMETER.

Each section of the shaft is provided with a spiral grip-thread, turned to fit a spiral spring of ¾-in. pitch. These threads are shown in the lower half of Fig. 2. The sections are also fitted with jaw collars, shown in the upper half of Fig. 2, that are turned to the same pitch. They have their spiral jaw surfaces cut to overhang the shaft, and make an angle of 45° with the shaft surface. The jaw collars, when forced into position by the lock nuts, with the aid of a spanner wrench, hold the end turns of the springs very securely, preventing them not only from slipping around the grip-thread, but also from springing out when the direction of rotation is such as to tend to unwind the spring.

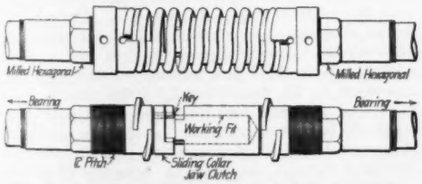

Fig. 2.—Details of Shaft and Spiral Spring Clutch-Jaws of Dynamometer.

All the spirals used with the dynamometer must have a pitch of ¾-in., and be wound to snugly fit a shaft 2 19-32 ins. in diameter. The jaw will securely hold springs from 0.2-in. to 0.6-in. in diameter, but necessarily the larger springs give a more stable adjustment and add stiffness to the instrument, considered as a transmitting device. Within the capacities of the spring, therefore, comparing them relatively to one another, the conditions for accurate work are more favorable with the larger springs. All the experimental work referred to here, however, was carried out with a spring made of standard No. 5 steel wire, which is slightly over 0.2-in. in diameter.

On the free sections of the shaft, shown between the hexagonal sections and the oil grooves, are mounted two instantaneous contact wheels, insulated from the shaft by hard fiber bushings. Each of these wheels, which are shown in Fig 1, carries at its rim a contact edge made of sheet brass and set parallel to the shaft in a hard fiber plug, driven into an inverted V groove, and turned down flush with the surface of the wheel. The contact points are grounded on the shaft, and are therefore in electrical connection with one another, although insulated from the contact wheels. Two brush holders mounted on the dynamometer bearings, and carrying 90° graduated scales, supply the brush supports and complete the contact devices; they provide for the possibility of obtaining readings when the angular deflection of one wheel rim contact point is 180° from the other. The brushes are carried on insulated brush rods and are connected with one another through several primary cells and a telephone receiver, all in series. This adjustment supplies the means of detecting when the brushes are so placed that the contact points on the wheels pass under them at the same instant, since at such times a "click" is heard in the telephone at each revolution of the dynamometer shaft.

The description thus far given indicates with sufficient clearness the method of using the dynamometer and of obtaining instantaneous readings of the torque exerted by the driving element at any time. When, in the case illustrated, the motor is started up, the angular deflection between the contact points is increased above its initial value until the resistance flexure offered by the spring overcomes the frictional resistance of the generator, and motion is imparted to its armature. If, by speeding up the motor or loading down the generator, conditions are varied so as to increase the resistance to motion between the two machines, there will be a still further deflection of the spring until the balance is restored between the forces acting. The variation in the angular deflection is quickly and easily followed by shifting the contact brushes until the "click" occurs in the telephone. In case the "click" is not sufficiently pronounced, a condenser is connected in parallel with the telephone receiver, and its capacity adjusted until the "click" is sharp and clear cut. If ordinary conditions of constant load are maintained, such as are usual in any laboratory test, the "click" in the receiver will be kept up at a constant frequency, and the relative motion between the contact points will be zero, as shown by repeated trials, even when the smallest spring is used; and when a suitable tachometer is at hand, ideal conditions are presented for making instantaneous determinations of the power transmitted.

In testing a given motor, the best results have been obtained by using a spring which will give a deflection of 180° when the motor is fully loaded. The brush setting admits of an accuracy within 0.2 of one degree, and thus the determination of the full load torque can be obtained within 0.1%. This compares favorably with the results obtained with the usual laboratory electrical instruments.

Calibrating the dynamometer is rapidly and easily effected with the aid of long wrenches. These are adjusted on the hexagonal sections of the shaft, one being used as a scale arm and the other as a lever. For any given point the lever is drawn over till the scale arm shows a tendency to raise from its horizontal position; the brushes are then placed on the contact points and adjusted till a clear "click" is obtained in the receiver on making and breaking the battery circuit; and a record is made of the scale arm moment and the deflection scale reading. The calibration curve of the dynamometer fitted with the lightest spring is shown in Fig. 3, and repeated tests before and after use fail to show any change in its calibration constants.

A spring can be taken out and another substituted for it in about five minutes, and the dynamometer can be calibrated in five minutes; but best of all, perhaps, it can be put in the hands of inexperienced experimenters, after having once been adjusted, and be used by them with success, as there is nothing to get out of order.

When the load on the dynamometer is subject to rapid variations, the clutch, shown at the center of the shaft in Fig. 2, should be moved over to the right. It will then lock with the jaw on the right hand section of the shaft in case the deflection exceeds 90° and prevent the possibility of the spring being overstrained.

Drawings have been prepared for a differential gearing attachment, which will register at any moment the torque developed by the machine. A device has also been worked out whereby the amount of deflection of the spring can be read directly from an ammeter connected to a battery through a variable resistance controlled by the dynamometer. The added mechanism will complicate the apparatus somewhat, but may appeal to those who especially favor a direct-reading instrument.

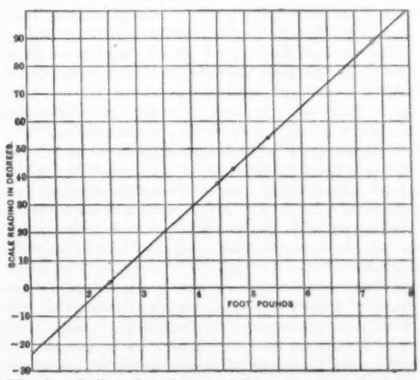

Fig. 3.—Calibration Curve of Dynamometer Spring.

*Abstracted from a paper read before the American Institute of Electrical Engineers.

†Professor of Electrical Engineering, Purdue University, Lafayette, Ind.

BIDS FOR THE NEW PACIFIC CABLE will soon be invited by the British authorities, as the various colonial governments interested have accepted the recommendations of the committee appointed to consider the project. The announcement was made recently by Mr. Joseph Chamberlain, Secretary of State for the Colonies. The cable will run from Canada to Australia.

THE PROPOSED FILTRATION PLANT for Providence, R. I., seems about as far distant as ever. The board of aldermen has indefinitely postponed the resolution appropriating $176,000 for mechanical filtration. A press report states that the vote was unanimous.

BUILDING A SEWER UNDER A VIADUCT PIER has been successfully accomplished at Cleveland, O., where the new 16-ft. Walworth River sewer passes under one leg of one of the trestle bents of the Abbey St. viaduct. The structure was shored up by heavy vertical timbers, and wire cables were run to the cap stone of the pier, so that when the timbers and cables were tight the steel leg and the cap stone on which it rested were raised ¾-in. clear of the body of the stone pier, which was about 12 ft. deep, 10 ft. square at the bottom and 7 ft. at the top with a concrete foundation. This was cleared away and a brick arch built for the sewer, the thickness of the brickwork being nearly 6 ft. under the site of the pier. This pier was then rebuilt, and the cables and wedges slackened to let the cap stone and steel leg return to their origina position: The contractors were Bramley & Gribben, and the work was done under the supervision of Mr. Ritchie, City Engineer.

INCREASED PASSENGER RATES have been put in force on the railways of Scotland. According to a consular report, the railways have begun a systematic effort to increase their revenues. Formerly there was practically no limit on the amount of personal baggage which passengers were permitted to take with them, but about a year ago an agreement was entered into by all the roads placing a limitation of 60 lbs. of baggage on a third-class ticket, and 120 lbs. on a first-class ticket. Charge is made for overweight. At the beginning of this year the rates for a certain class of "season" tickets known as "traders" were increased 50%. This has been followed by still another, going into effect June 1, which increases the price of return fares 20%. Third-class week-end tickets are increased from 3 to 20%. The reason given in the main for these decided advances is the increased price of coal, an advance of $1.20 per ton having taken place this year.

THE SPECIAL SYSTEM OF FIRE PIPE LINES in Philadelphia, proposed for early construction, was not acted on by the city councils prior to their adjournment. The estimated cost of the system is reported as $850,000. It included four 5,000,000-gallon pumps. The mains were to be laid on Market, Walnut, Arch and Race Streets.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page* XXIII. *New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

The coming meeting of the American Society of Municipal Improvements may well be borne in mind by municipal engineers and others interested in the construction and operation of city works when making their plans for the balance of the summer. The convention will be held at Milwaukee, Aug. 28 to 31, an extra day having been added to the program to give ample time for the many important subjects pressing for consideration. The society aims to cover the whole range of municipal public works, besides many allied questions, such as taxation and assessment, franchises and municipal data. A committee on the latter subject has been working for several years to devise and secure the adoption of uniform municipal reports. As we stated in our issue of July 5, the committee has prepared forms covering water-works, sewerage and paving. The society also has a committee on national municipal statistics, appointed to co-operate with similar ones from other societies in securing the collection of such statistics by the general government. Reports may be expected, we understand, from each of these committees, which, with the ensuing discussion, should prove to be of great interest and value. The list of cities having a membership in the society now numbers 80. As this is the only national organization covering the whole of the field indicated above, from its practical side, it certainly deserves, and doubtless will receive, a wider support than it has yet attained, although it has done well, in view of its recent origin.

The annual water famine in the borough of Brooklyn is announced by the newspapers, and has been declared imminent by the officials in charge of the Brooklyn works. Mr. Robert Van Buren, Engineer-in-Charge, officially stated, a few days ago, that there was only 3½ days' supply in storage. This alarming condition is not due to lack of water in the collecting area, but to an absence of facilities to get it to the city. Prior to consolidation, a 48-in. main from Millburn to Spring Creek was proposed, and the contract for it almost awarded. For some mysterious reason the award was not made. Since consolidation the water department has urged repeatedly that an appropriation be made and the conduit laid, but the matter has been in abeyance, or dragged slowly on, year after year. Finally, the appropriation bill reached the municipal assembly, where it has been "hung up" for weeks. For three years, Mr. Van Buren says, no work has been done "for the improvement, extension or protection" of the Brooklyn water supply, except the erection of a $6,000 steel chimney at the Mt. Prospect station, and the money for that came out of the water revenue. Besides the 48-in. conduit, there are needed new pumping stations and a filtering plant to utilize water otherwise unavailable.

Mr. Jas. Moffett, Deputy Commissioner of Water Supply for Brooklyn, makes the following official comment on this strange situation:

> It is a sad commentary on municipal government when such a state of affairs exists that the duly elected officials of the second city in the world, whose bounden duty it is to appropriate the necessary moneys to make available for use the water which is running to waste at its very doors, have become so utterly oblivious of their oath of office as to permit the inhabitants to reach an absolute lack of water.

This sounds wonderfully like the utterances from Philadelphia during the period when the gas-works were being wrecked so that they might be turned over to a private company, as they finally were, and very like the warnings from the same city when the water-works were being starved to the same end. The latter attempt seems to have failed completely in Philadelphia. There is reason to hope that if a similar one is and has been at the bottom of the Brooklyn delays, all along, it also will be thwarted. That the Brooklyn works was the object of the Ramapo promoters for the ten years prior to the time their prey was enlarged through consolidation there is much reason for believing. For years past the Brooklyn water supply has been the subject of attack from certain quarters on all possible occasions. Its alleged inadequacy, impurity, expensiveness and legal complications, through affecting private rights in ground waters, have been exhibited in kaleidoscopic succession until the people of Brooklyn seem to have become incredulous and indifferent. It is high time that they awake to their danger, and insist on the immediate prosecution of the works planned years ago, and doubly or trebly necessary now, to make available the supply already developed and daily going to waste.

THE DEVELOPMENT AND FUTURE PROSPECTS OF PORTLAND CEMENT MANUFACTURE IN AMERICA.

In the manufacture of natural rock cement the United States has for years unquestionably led all other countries both in the quantity and in the high quality of that important structural material which it produces. The manufacture of Portland cement on a comparable scale, however, has been a development of the last few years. Indeed, so recent and so rapid has its growth been that it is scarcely realized even by those who have watched it most closely that this country now rivals England, the birthplace of the industry, in its annual output of Portland cement, and bids fair within the next decade to dispute the palm with Germany as the greatest Portland cement-producing country of the world. This reversal of the conditions of a few years ago when the Portland cement works of the United States were an insignificant factor in supplying even the domestic consumption of that material very naturally raises the questions: (1) To what is this gratifying change due? and, (2) what is the likelihood that it will endure. In so far as brief space will permit the attempt is made here to answer those questions.

By general consent the credit of first manufacturing Portland cement as an article of commerce is granted to England. Nominally at least, if not actually, Joseph Aspdin, a brickmaker of Leeds, was the father of the industry. Aspdin was granted his patent for the manufacture of Portland cement in 1824. From this time on the new cement was engaged in a struggle for recognition until the experiments of Mr. John Grant, M. Inst. C. E., made for the London Drainage Works in 1850, finally established it as a material upon which engineers could rely to the fullest extent. In 1846 the manufacture of Portland cement was first commenced in France, near Bologne. The first German Portland cement works were established at Stetten, in the now famous Harz Portland cement district, in 1855. From these countries the industry spread to other parts of Europe, Russia, Austria, Switzerland and the Scandinavian states, all commencing its manufacture within a few years.

So much for the beginnings of the Portland cement industry in Europe. For a quarter of a century England maintained the lead as a manufacturer of Portland cement, which its priority in the field had given it, and, which its vast deposits of wonderfully pure and easily-worked raw materials helped it to maintain. Then for twenty years English methods of manufacture and English Portland cements remained practically unimproved. As a natural result England's export trade in Portland cement was taken away from it by the more progressive Continental manufacturers, and they finally began to threaten seriously even the home market. Alarmed into action by those encroachments English cement makers have within the last five years bestirred themselves with notable success toward improving their methods and product, but the prestige which had been lost through previous neglect will probably never be regained. At the present time the annual output of Portland cement in England is between 7,000,000 and 8,000,000 barrels.

French chemists had been among the very first to establish the true principles of hydraulic cement, and French Portland cement works, as has already been seen, had been started at an early date, but the commercial development of the industry made comparatively little progress until about 1880. Even now the French cement trade does not extend much beyond the home market, a few adjacent European countries, and the nation's colonial possessions. As a result French cement works and their products are not well known abroad. Notwithstanding all this it is questionable if any country can justly claim to have a Portland cement industry which is based on greater experience, or whose technology is established along more scientific and progressive lines. The weakness of the French cement maker has been in the commercial development of his business. France to-day makes barely 3,500,000 barrels of Portland cement annually.

Considered both technically and commercially the manufacture of Portland cement in Germany has exhibited the most notable growth, although, as will be pointed out later, the United States now bids fair to rival it in both respects. The original works established at Stetten in 1855 produced 30,000 barrels of cement during the first year of their operation. In 1877 the number of factories had increased to 29, producing 2,400,000 barrels each year, and in 1896 it had increased to 42, producing 5,700,000 barrels each year. At the present time the annual output of something over 70 German Portland cement factories is between 18,000,000 and 20,000,000 barrels. Of this total output between 3,000,000 and 4,000,000 barrels are exported, the great bulk of this export trade being with the United States.

This great success of the Portland cement industry in Germany has doubtless been due in a very large measure to its remarkably good organization both commercially and technically. German cement makers first set themselves to work by every means in their power to make a good reliable cement, and next to make it known to cement users that they did this. How well they succeeded is known to American engineers as well, perhaps, as to any one, since they have used it to a greater extent, probably, than any others outside of Germany, and since it yet stands as a criterion of reliability and high quality in Portland cements in this country. This is not a small achievement, as manufacturers everywhere will testify, and it has been due to the perfect organization of the industry brought about in Germany largely through the efforts of the German Portland Cement Manufacturers' Association.

This association is made up of chemists, engi-

neers and cement manufacturers, and was organized for mutual protection and for the study and development of information concerning the industry. As examples of the good work that it has done, it may be observed here that almost its first task was to stamp out the practice of adulterating Portland cement then prevalent in Germany. Its next work was to establish standards of quality and to bring manufacturers to observe them. How well were both these tasks accomplished that one of the most notable properties of German Portland cement is its general reliability. To attempt even to outline the work of this organization here is impracticable. It can be indicated in measure, however, by saying that very few associations of manufacturers have done as much to develop the industry which they represent and to advance the knowledge concerning their product as this society of German Portland cement manufacturers. It would be interesting, also, to examine how far, under the present conditions of the Portland cement industry in America, the manufacturers of the United States might profit by this page from German experience, but the mere suggestion is all that is possible.

Having co-ordinated ourselves in a general way with the conditions of the Portland cement industry abroad, we are in a position to examine its development in America with greater intelligence. It is generally conceded that the origination of the industry in this country is due to the labors of Mr. David O. Saylor, of Coplay, Pa., to a greater extent, perhaps, than to those of any other one man. Mr. Saylor was a manufacturer of natural rock cement at Coplay, when in the early seventies he turned his attention to the possibilities of adapting his raw materials to the manufacture of Portland cement. After numerous experiments he discovered the secret for which he was searching. Examined with our present knowledge it seems a simple one, but backsight is a far different thing from foresight, and Mr. Saylor was working from the latter point of view, and with a material never before used for making Portland cement. Described in the briefest possible way, the secret was simply to break down the natural rock into an impalpable powder, remix its separate particles, mold them into bricks with water, and then dry, calcine and grind these bricks. The kernel of the secret was the breaking down of the original material to a powder, and this is to-day the standard mode of procedure throughout the United States where limestone or cement rock provides the raw material. To trace the whole course of Mr. Saylor's experiments would take too long; it is sufficient to note that they had attained sufficient success to enable him to exhibit American Portland cement at the Continental Exhibition of 1876 which compared very favorably with the foreign brands exhibited by its side.

During the time Mr. Saylor was bringing his work to a successful conclusion at Coplay, or within a short time afterwards, works for manufacturing Portland cement were established at Rondout, N. Y.; at Kalamazoo, Mich., in 1872; at Wampum, Pa., in 1876; at South Bend, Ind., in 1877; and at Rockland, Me., in 1879. Of these five works only two, those at Wampum and South Bend, survived. Previous to 1881, therefore, only six Portland cement works had been started in America and three of these were failures. The chief cause of these failures, as has been pointed out by Mr. Robert Lesley, of the American Cement Co., who was himself one of these early investigators, was the cost of reducing the raw materials and getting them into the kilns for calcination. This reason hardly holds good in respect to the Rondout, N. Y., works, however. It was at these works that Mr. J. Gardner Sanderson, M. Am. Soc. C. E., began the first experimental work done with the rotary kiln, and he had brought this device to a fair measure of success when his plant was destroyed by fire and he abandoned the field of cement manufacture.

The factors which wrought success from this unfavorable beginning were the outcome almost wholly of American ingenuity. Before reviewing them, however, it will repay us to examine briefly the extent of the development which they have accomplished. In the accompanying diagram the full line shows the domestic output of Portland cement from 1883 to 1899, inclusive. It will be observed that the annual increase from 1883 to 1895 averaged about 70,000 barrels; then the production took a jump of 553,000 barrels within the next twelve months. The increase for each succeeding year over the year previous was: for 1897, 1,134,000 barrels; for 1898, 1,018,000 barrels, and for 1899, 1,454,000 barrels. Summarized, the production of 1899 was over five times as great as that of 1895. This is a record of growth which is justly comparable with that boasted in by German cement manufacturers. For the twelve years from 1886 to 1898 the annual increase in the production of Portland cement in Germany averaged slightly over 1,000,000 barrels. For the four years from the end of 1895 to the end of 1899 the annual increase in output in the United States was at almost exactly the same average rate. It would be unwise, perhaps, to assume that this record will be maintained in the United States for as long a period as it has been in Germany, but as will be pointed out immediately there is considerable reason to believe that such an assumption might not fall so very wide of the mark.

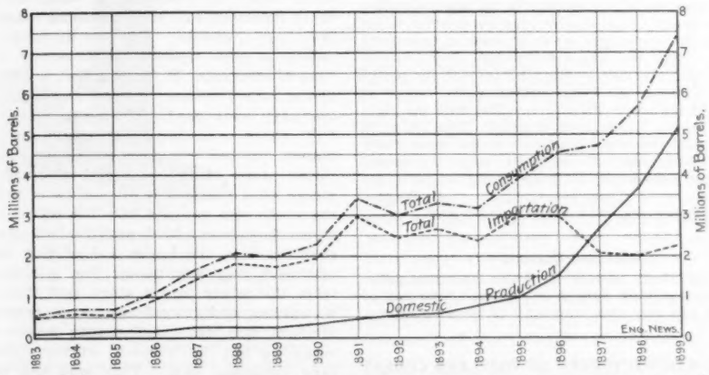


DIAGRAM SHOWING DOMESTIC PRODUCTION, IMPORTATION AND TOTAL CONSUMPTION OF PORTLAND CEMENT IN THE UNITED STATES FROM 1883 TO 1899, INCLUSIVE.

The causes of the rapid development of Portland cement manufacture in America, and likewise the reasons why we are justified in expecting this rate of growth to continue are contained in the following general propositions: (1) All indications point to a constantly growing market for Portland cement in America for many years to come; (2) a method of manufacture has been developed which for American conditions at least is a decided improvement over the methods practiced in any other country; (3) as a result of the second fact American Portland cements equal in all respects to the best foreign cements can be made and sold at a smaller price than these foreign products can be imported, and (4) the last fact is becoming realized by cement users.

Turning to the accompanying diagram it will be seen that despite the fact that the production of Portland cement in the United States increased fivefold between the end of 1895 and the end of 1899, it had at the end of the latter year gained only 728,000 barrels on the total consumption. Stated in another way, 2,997,000 barrels of Portland cement had to be imported in 1895 to meet the excess in demand over domestic supply, and in 1899, only 728,000 barrels less, or 2,269,000 barrels had to be imported to meet the same excess demand. Assuming that the domestic supply and the total consumption continue to increase at the same relative rate that they have maintained since 1895, it will take over twelve years for American Portland cement mills to increase their output sufficiently to supply the home market.

The question which naturally arises here is: Are we justified in assuming that the next ten or twelve years will witness the maintenance of the remarkable increase in the consumption of Portland cement in America which the past four years have exhibited? A definite answer to this question is obviously impossible. It can be said, however, that at the present outlook no diminution, but rather an increase, in consumption is indicated for the immediate future. Cement makers evidently foresee no reason to feel doubtful of the future if the rapid building of new works and additions to their present plants may be taken as reliable evidence. A more encouraging fact than either of these, however, is the rapidly increasing favor which hydraulic cement is gaining among engineers as a structural material. This is not evidenced so much by the fact that new uses are being found for Portland cement as it is by the fact that it is being employed in greater quantities than ever before for familiar purposes. Even with its recent rapid development in this direction, however, America is far behind Germany in respect to the extent to which cement is used for structural purposes. On the whole, therefore, the conditions would seem to be exceptionally favorable for continued increase in the consumption of Portland cement in America.

The next question evidently is: Can we expect a continued development in domestic production equal to this possible demand? This question may be answered by saying that, given the raw materials to work from, the capital to work with, and the market to consume the product, it is only a matter of developing a method of manufacture which will enable cement to be produced which can compete in quality and cost with the imported material. The reasons why the market seems assured have already been stated, and we hardly need to say that capital will not be wanting to invest in cement manufacture when once it is certain of a reasonable return for its use, and this is assured as long as the present market conditions endure. The problem, therefore, simmers down to the questions of an available supply of suitable raw material and the means for its economical manufacture.

In its supply of suitable raw materials for Portland cement manufacture the United States is probably on a par with any of the leading foreign cement-producing countries. It would be easy to present details in proof of this statement, but a brief mention of some of the kinds of raw materials used, and of the widely-distributed sources from which they come will furnish pretty satisfactory evidence of its truth. In 1898, according to the U. S. Geological Survey, Portland cement was produced in 13 states, these embracing states as widely separated as New Jersey and California and South Dakota and Arkansas. In fact, wherever the water-limestone and marls of the Silurian formation or the chalks of the cretaceous formation occur in the United States suitable material for making Portland cement seems quite certain to exist. At the present time the bulk of American Portland cement is produced from the water-limestones of Pennsylvania, New Jersey and New York, and the marls and clays of New York, Ohio and Michigan. The materials employed in South Dakota and Arkansas are clay and a species of chalk. One works in Illinois and one in Pennsylvania employ blast furnace slag and limestone, and one in Michigan uses clay and the lime waste from a caustic-soda plant. It will be observed from the preceding statements that the raw materials in actual use are quite numerous and varied. It is proper to observe that while all these materials are in actual use, the great bulk of American Portland cement, probably

fully 70%, is made from water limestone, the deposits of which are almost unlimited in certain localities.

It is not so much in the nature and quantity of its raw Portland cement materials that the United States commands particular notice as compared with other cement-producing countries, as it is in the methods which have been evolved for converting these materials into the finished cement. The rotary kiln is distinctively an American development, and it is to the success of this device more than to any other single improvement that the American Portland cement industry owes its high position at the present time. Without going into extensive details, a few words are required to support the accuracy of this assertion.

In its methods of breaking down the raw materials, combining them into a raw mixture and regulating the composition of this mixture American practice does not differ essentially from the best practice abroad. From this point on, however, American practice shows an improvement over foreign. The English and Continental maker, if he employs the so-called dry process, has next to wet his mixture, mold it into bricks and then dry these bricks, or else, if he employs the wet process, he has to run his wet mixture on to drying floors, evaporate the water and break up the dried mass, before it is ready to put into the kilns for calcination. The American manufacturer, on the contrary, runs his mixture just as it stands, as a dry powder, or as a wet slurry, directly into his rotary kilns, from which it emerges perfectly calcined. All the time and labor of brickmaking, drying and preparing the mixture for the kilns which the European manufacturer has to consume is avoided by his American competitor. Furthermore, the European maker, because of his practice of calcining his mixture in the form of large bricks or lumps, has to crush his clinker before it can be admitted to the grinding mills. The clinker from the rotary kiln seldom requires this preliminary crushing, but may be handled directly by the grinding mills. Here again is another important saving in time and labor. Finally, despite its comparatively large consumption of fuel, the output of the rotary kiln is so large and its cost for labor so small that it produces cement at a smaller cost per barrel under American conditions than is generally possible by any other form of kiln. Taken altogether these facts account for the circumstance that to-day probably fully 90% of the Portland cement being made in America is calcined in rotary kilns.

Turning now to the quality of American Portland cements, as compared with those of foreign production, we find a fairly representative comparison in the diagrams published in the Annual Reports of the Department of Public Works of the city of Philadelphia, Pa., which are too familiar to engineers to require publication here, even if they did not take up too much space for these columns. These diagrams are graphical representations of the comparative tests made at the Testing Laboratory of the Department, and they are self-explanatory. Briefly, they show that in all the physical properties for which such cements are ordinarily tested by engineers, American Portland cements are equal to, or superior to, those produced anywhere in the world. That American cement users are coming to appreciate this fact is made evident by the fact that the domestic product finds a ready market in competition with the best foreign cements.

In the foregoing paragraphs we have endeavored to present some of the reasons for the notable development of the Portland cement industry in America, and for the belief which we have that this industry has a prosperous future before it. It cannot be pretended that more than the barest outline has been given of all these things, but the road is open to any one who wishes to go further into details. Finally, it is interesting in connection with what has been said to revert to a bit of history which is not remembered by many. In 1882 the leading argument made before the Morrill Tariff Commission of Congress why Portland cement should be put on the free list was that there was no likelihood of Portland cement manufacture being established in the United States for the reason that there were no raw materials from which it could be made economically. Fortunately there were men who stood ready to prove the contrary, and when it was once started American ingenuity and skill eventually succeeded, as it has done many times before and since, in excelling the foreign product both in quality and cheapness.

LETTERS TO THE EDITOR.

Tracklaying by Machine.

Sir: Noting the mention of tracklaying by machine on the Canadian Pacific Ry. and the St. Louis, Oklahoma & Southern Ry., in your issues of June 14 and July 5, I wish to state that on the Chicago & Northwestern Ry. we have completed 134 miles of tracklaying with the Roberts' machine this season and that during the greater part of this distance we laid 2½ miles per day, the days averaging about nine hours each. Yours truly, C. T. Dike,
Div. Engr., Chicago & Northwestern Ry.
Mason City, Ia., July 7, 1900.

Methods of Interpolating Contour Points.

Sir: I would suggest a still simpler method of interpolating contour points than any of those described in your issue of June 21. Take a narrow strip of India rubber, stretch it well, and while stretched mark on it a pretty coarse scale. When the rubber is relaxed you will have a very fine scale, and coarser or finer as you pull more or less. To use it, place the relaxed scale so that the proper division will coincide with the given elevation on your left hand. Hold that division very firmly at the point where the elevation is given by pressing down hard on it with a little tool like a dull chisel. Then, having a heavy weight attached to the other end of the rubber scale, move that to the right, stretching the rubber as you go, until the proper division coincides with the right hand point where the elevation is given. Then let go of the weight with your right hand, the weight being heavy enough to hold it, and mark with your pencil the desired points. Other devices may be preferred for operating the elastic scale. Truly yours, C. D. Ward.
702 St. Nicholas Ave., New York, June 21, 1900.

Notes and Queries.

The address of Mr. George E. Hyde, late topographer on the U. S. Geological Survey, is requested from any of our readers who may have knowledge of his whereabouts.

THE FIRST MANUFACTURERS OF PORTLAND CEMENT BY THE DIRECT ROTARY KILN PROCESS.

By E. Duryee.*

The original practice in making Portland cement by the rotary kiln process was to rekiln the material, first putting them through a wet mixing process, then drying, and, in some cases, regrinding them, before introducing them into the calcining kiln. This was originally the practice at the Sandusky, O., plant, to which an editorial in the Engineering News of May 3 awards the honor of originating the practice of direct burning of the wet slurry in a rotary kiln. Professor Newberry, of the Sandusky works, on a visit he made to the Montazuma, N. Y., plant, told the writer that he was first drying his wet materials before introducing them into the burning kiln. At that time the direct process had been in operation at the Montezuma works for about two years, and upon the writer's explaining the process followed there to Prof. Newberry, and stating that it worked satisfactorily, the Professor expressed the opinion that it was certainly the most rational process. So far as the writer has been able to learn, the first works commercially to make Portland cement in rotary kilns without rekilning, wetting, making into bricks, or drying the raw materials was that of the Walkill Cement Co., at Rondout, N. Y. (Eng. News, May 31, 1900), where the process was inaugurated in the fall of 1888. The raw materials used at Rondout were cement, rock and clay in a dry condition. The first works to manufacture direct from the wet raw materials by introducing them while wet into a mixing machine, then into a mill, and thence directly into a calcining kiln, from which the finished clinker was delivered, was the plant at Montezuma, N. Y., where this custom was successfully followed in 1890.

Rotary kilns had been in use some years for treating ores before they were used in 1885 by Ransome for burning cement. Dr. George Duryee patented a rotary kiln in 1881 for metallurgical purposes, and it was that form of kiln that [illegible] J. G. Sanderson, who was looking for an improved form of kiln to use in burning cement at his works at Rondout, adopted in October, 1888. The success that attended the first efforts of Messrs. Duryee and Sanderson in making cement by direct burning of the raw materials, may be attributed largely to the greater length of their kiln. Whereas other makers in their early work used kilns about 30 ft. long, the one built at Rondout was 70 ft. long and 50 ins. in diameter. The upper end was first made 50 ins. higher than the lower end but later changed to 30 ins. higher. The works in Pennsylvania used kilns 30 ft. long as late as 1892, at which time one 75 ft. long was built at Montezuma, N. Y. The writer has been running kilns of the latter length in California since 1893.

The dry process was followed at Rondout until the works were destroyed by fire. To the best of the writer's knowledge the next works to adopt the direct dry rotary process were those at Colton, Cal., which started in April, 1893, and have been in successful operation since that date. The custom there is to crush the limestone and air-dried clay separately, then mix them and pulverize them in a Griffin mill. The raw material is then fed directly into a rotary calcining kiln. This kiln is 75 ft. long, the lower end of which for 20 ft. is 6 ft. in diameter, and the remaining length of which is 5 ft. in diameter. The raw materials consist of calcite, a pure crystallized limestone, and a clay.

At Montezuma, N. Y., the first works to use the direct rotary process on wet raw materials, marl and clay were used. The marl, containing about 50% water, was dug by a steam dredge from a marsh, dumped into cars, which were run into the upper story of the mill and alongside a power mixer, that steamed it as well as mixed it. After the marl was dumped into the mixer the clay in slurry form was added, and the two mixed as they gravitated to the lower end of this mixer. The operation was continuous, the mixture running from the mixer into a stone mill that completed the mixing and ground any coarse materials. The mixture was fed continuously from this mill, steaming hot, by a screw conveyor into the rotary calcining kiln. This was the practice at Montezuma, in the fall of 1890, and continued to be followed there successfully until those works burned down.

*Chemist California Portland Cement Co., Colton, Cal.

BOOK REVIEWS.

MODERN AMERICAN SCHOOL BUILDINGS.—A Treatise Upon and Designs for the Construction of School Buildings. By Warren Richard Briggs, F. A. I. A. With 89 full-page illustrations. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 6 × 9 ins.; pp. 411. $4.

This book begins with the discussion of the general problems involved, including the importance and magnitude of the architectural field in question. The practical and often extremely troublesome problems of appropriations and competitions are next discussed, after which an earnest plea is made for specialists in school architecture, reasonable compensation to architects and the proper superintendence of the construction of buildings. A few pages are devoted to professional ethics, in which the author takes a dignified stand against "hustling for business." The chapter on "Ready-Made Plans" deserves wide attention, particularly the portion relating to plans of this class published by private enterprise.

The several chapters on the actual design of school houses seem to be sound in general principles, but they must be taken, for the most part, as illustrations of the practice of a single architect, rather than the most advanced thought of the profession as a whole, except in so far as the author's ideas conform to such thought. Books written on this plan, if the product of able and experienced men, as this one seems to be, are often of great value because of the very limitations involved, but the limitations should not be forgotten.

The book contains comparatively little on building construction; that is, the selection and proportion of materials; nor does it go much into any of the details, further than is required to set forth the general principles involved. On the æsthetic side, strange to say, the book appears to be almost barren, so far as specific utterances go. One would expect to find at least a single chapter on the relation of school house architecture and decoration to the development of a proper appreciation of art in the child. The book is a valuable addition to the literature of the subject, but why the publishers should allow a book of 411 pages to appear without an index we will not attempt to explain.

IRRIGATION AND DRAINAGE.—Principles and Practice of Their Cultural Phases. By P. H. King, Professor of Agricultural Physics in the University of Wisconsin. New York: The Macmillan Co. Cloth; 5 × 7 ins.; pp. 302; 163 illustrations in the text. $1.50.

As indicated by the sub-title, this book is devoted to the cultural phases of irrigation, rather than those pertaining to engineering. From that point of view it appears to be a pretty comprehensive work. Certainly it contains a vast amount of information on the relations between moisture, soils and vegetation. Of particular interest to engineers will be the sections relating to the amount of water required by different crops, the conservation and utilization of ground water by manipulations of the surface and sub-surface; the various methods of distributing water to crops; and the use of sewage for irrigation. In discussing sewage irrigation, the author does not seem to be aware of the extent to which sewage disposal by intermittent filtration is practiced in this country, and therefore the readiness with which it may be employed to supplement sewage farming in cold climates. As a matter of fact, most of the American systems of sewage disposal on land make use of intermittent filtration rather than broad irrigation, and the greater number of such systems are in the Northern States and in Canada. It may be said in conclusion that this volume is one of "The Rural Science Series," edited by Prof. L. H. Bailey, of Cornell University.

FIG. 2.—THE UNION TRACK JACK.
E. M. Robinson, Inventor.
Morden Frog & Crossing Works, Makers.

THE RAILWAY SYSTEMS OF BRAZIL.

In the absence of any general governmental or private publication on Brazilian railways, Mr. Thomas C. Dawson, U. S. Secretary of Legation in Brazil, has collected such information as is available concerning the railway system of that country and submitted it in the form of a report to the Secretary of State. At the beginning of his report Mr. Dawson states that government railways and railways aided by the government make reports to the Brazilian Minister of Public Works, but no system is observed, and no two reports are alike in the items dealt with. In addition to these reports Mr. Dawson has made use of reports to stockholders and separate State publications. With this caution regarding the miscellaneous sources of his information he gives the following general statement of railway conditions in Brazil:

There are now in Brazil 63 separately operated lines of steam railways aggregating 9,197 miles under traffic. Of this total 908 miles are broad gage, or 5 ft. 3 ins.; 7,742 miles are 1 m. gage, or 3.28 ft., and 551 miles are 0.75 m., or 2.46 ft. gage. The government operates five lines having a total length of 1,287 miles; the States own four lines of 110 miles; guaranteed companies operate 4,587 miles, and non-guaranteed companies 3,213 miles. The Union and the States have constructed 2,131 miles.

As the population of Brazil is mainly scattered along the coast line and the large cities—with one exception—are on the sea coast, the railways are divided into separate systems, each having its terminus at a different port; and only two of these systems are connected. Commencing at the north these systems are enumerated as follows: Para, with a single short line of railway; Maranhao, with one short line beginning a considerable distance up the navigable river Itapicura, which enters the sea at this port; Camocim, in the State of Ceara, one line; Fortazela, the principal port in the same State, one line; Natal, the capital and port of Rio Grande do Norto, one line; Parahiba, capital of the state of the same name, one line; Recife, or Pernambuco, from which six lines radiate fairly covering the eastern part of the State, and connecting with the next system by its southern lines; Maceio, capital and port of Alagoas, one line; Piranhas, a river port at the head of navigation on the lower San Francisco, with a line running around the cataracts in the river; Bahia is the center for four lines; Caravellas, the southern port of the State of Bahia, one line; Victoria, the capital of Espiritu Santo, one line under construction intended to connect with the Rio system; Cachoeiro da Itaperim, an unimportant port at the head of navigation on the river of that name, will shortly be connected with the next system by rail.

Rio de Janeiro is the center of the most important railway system which has a total length of 3,700 miles and covers the State of Rio de Janeiro and the southern part of Minas Geraes. This system is connected at two points with the next, and the two practically form one system. Santos, the sole port of the principal coffee state, Sao Paulo, has a railway system of over 2,000 miles. Laguna, a small port of Santa Catharina, has one short line; Paranagua, the port of the State of Parana, has one considerable line which will soon connect with the Sao Paulo system; Porto Alegre, the capital and second port of Rio Grande do Sul, has four lines; and one of these is shortly to connect with a line leading from Rio Grande, the most southerly seaport of Brazil. Uruguayana, on the Uruguay River, has one line connected with the railways of the Republic of Uruguay.

The first railway in Brazil was opened to traffic in 1856; it ran from the head of Rio Bay to the summer capital of Petropolis, and was built by private enterprise. With this exception the early railways were built with government assistance.

In his report which forms No. 758 of the U. S. Consular Reports, Mr. Dawson then enters into such detail of each line as he was able to collect, treating of the ownership, organization, income and operating expenses. As this detail occupies very considerable space, the interested readers must be referred to the report itself. According to the last publication attempting to treat of the general subject of Brazilian railways—a sketch published in 1889 by Fernandes Pinheiro, the statitics for 1887 were as follows: Lines in operation, 5,273 miles, cost $294,000,000; the receipts for 1887 were $22,716,000, and expenditures for operation were $15,613,000, leaving a net surplus of $7,103,000, or 2.4%. For the year the total number of passengers carried was 360,000,000, and 2,100,000 metric tons of freight were carried.

Owing to the fact that, as a rule, a considerable chain of mountains rises abruptly a short distance from the coast, with an interior plateau seamed with deep and tortuous rivers, the building and operation of railways in Brazil offer peculiar engineering difficulties. Tunnels, steep grades and crooked lines are characteristic. Mr. Dawson presents an estimate made for a line, 124 miles long, running from Bello Horizonte, across the high Minas plateau to a connection in the west of Minas. This estimate which is supposed to cover average conditions, foots up to $2,543,850, or about $20,515 per mile. And this is based upon very low prices for labor, which is as low as 21 to 28 cts. gold per day to section hands; with 14 to 21 cts. per day on interior lines. In 1898, says Mr. Dawson, the Sao Paulo Railway Co. removed 582,000 cu. m. of earth, on its duplicate line up the serra, at a cost of $114,000; about 19½ cts. per cubic meter, or 15 cts. per cubic yard. The report closes with statistical tables, giving stock and bond quotations, freight tonnage, cost of lines, number of employes and total salaries, gross incomes, etc.

THE UNION TRACK JACK.

The track jack illustrated in the accompanying cuts is of the ratchet type, but with special features in the operating mechanism. Fig. 1 shows the construction of the jack, and Fig. 2 is a general view. The bar has a cross section of 1¼ × 1¼ ins. at the root of the teeth, and the teeth have a pitch

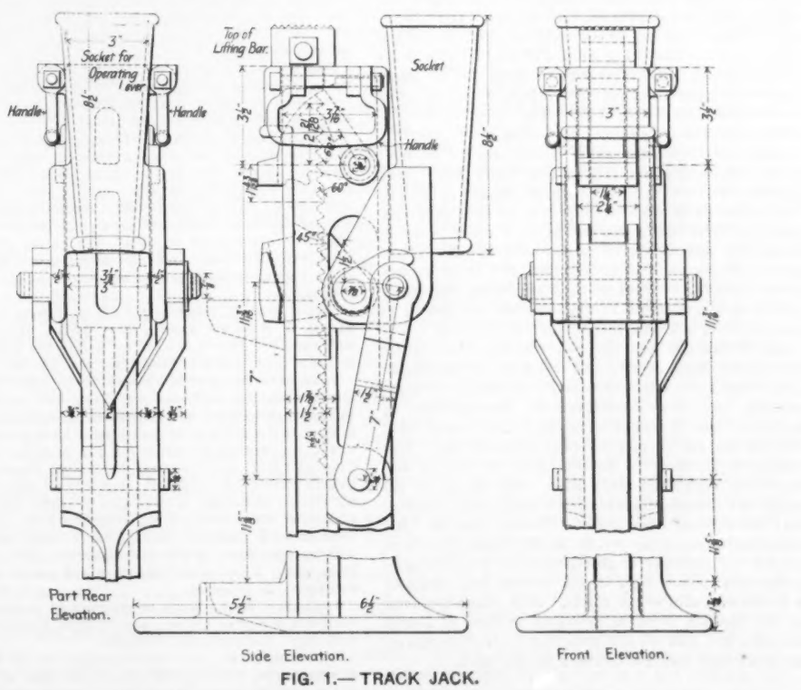


FIG. 1.—TRACK JACK.

of ½-in. Within the frame are two pawls, one above the other, with segmental side plates or wings on either side of the bar and extending around the front of the bar. The lower pawl is operated by the lever, while the upper one holds the bar in the position at which it is set at each stroke. In order to give a vertical movement to

the lifting pawl, without any rocking motion in the tooth, the pin of the pawl works in a vertical slot and the operating lever has a movable fulcrum on a pair of links pivoted to the frame. By this arrangement the pawl is also a clutch, and becomes practically a part of the lifting bar when it is engaged with the rack of that bar. All horizontal thrust against the bar, tending to force it against the frame as it is raised, is also avoided, so that there is no friction between the bar and frame, but all the power is exerted in lifting the load. This arrangement also gives a variable leverage. A full stroke of the lever will raise the bar three teeth, but a short stroke (with the lever near the horizontal) will give a very powerful lift of one tooth, the three points of support being nearly in a straight line and the operation being practically that of a toggle joint.

The method of tripping consists in raising the lower pawl so as to engage with and throw back the upper or holding pawl. This is explained by the diagrams in Fig. 3. In diagram No. 1, a complete downward stroke of the lever has been completed, and both pawls are engaged with the bar,

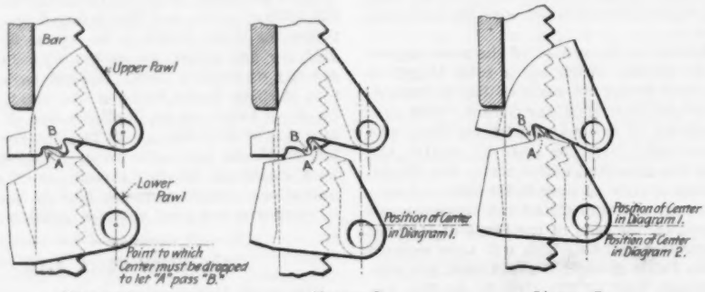


FIG. 3.—DIAGRAMS OF TRIPPING ARRANGEMENT OF THE UNION TRACK JACK.

while their lugs (A) and (B) are almost in contact. The wooden lever is then removed, and the lower pawl is depressed by raising the lever socket until the lug (A) is clear of lug (B) on the upper pawl. The lever socket is held in this position and the front of the pawl is raised by hand until it strikes the face of the bar, when (A) will be behind and below (B). The lever socket is then depressed, raising the lower pawl until it brings the lugs into the position shown in diagram No. 2, the lug (B) of the upper pawl thus holding the lower pawl clear of the teeth of the bar. The jack may be left set in this position, ready to trip, while the tamping or other work is done, the bar being securely held by the upper pawl. When it is to be tripped, the lever socket is still further depressed, thus throwing the upper pawl out of engagement with the bar, as shown in diagram No. 3, when the bar is free to drop.

The lifting bar and the pawls are of steel, while the frame, lever socket and links are of malleable iron. The size of the base is 7 × 12 ins., as recommended by the Roadmasters' Association of America, and the jack is made in four sizes with lifts of 12, 14, 16 and 18 ins., respectively. The weight is from 65 to 85 lbs., and the lifting capacity in each case is 12 tons. The parts on all jacks are interchangeable with each other, except that the ratchet bars are of different lengths. This jack was invented by Mr. E. M. Robinson, and is in use on the Chicago & Northwestern Ry., Chicago & Eastern Illinois Ry., Union Pacific Ry., Chicago & Alton Ry. and other roads. It is manufactured by the Morden Frog & Crossing Works, of South Chicago, Ill., and we are indebted to that company for drawings and particulars of the tool.

ENGINEERING WORK IN PROGRESS IN AND NEAR BOSTON.

In our issue of July 12 we commented briefly on the "Bulletin of New Engineering Work," which is now being issued by the Boston Society of Civil Engineers. To bring the possibilities of such bulletins before other engineering societies, and also because of the information it contains, we reprint the July bulletin* practically in full, as follows:

United States Government.—Dredging in Boston Main Ship Channel to a depth of 27 ft., at L. W. Laying underwater foundation of quarried granite for Sandy Bay breakwater, Rockport.

Commonwealth of Massachusetts, Metropolitan Park Commission.—Winthrop Shore Reservation: Recent completion of sea wall and shore drive along Winthrop Beach for a length of one mile.—Revere Beach Parkway: Three miles under construction to sub-grade in Revere, Chelsea and Everett, requiring a total of 300,000 cu. yds. of filling material. Work is being done by train and carts. Fresh Pond Parkway: Construction of a drive, half a mile in length, from near Cambridge Hospital through Lowell Memorial Park to Huron Ave., near Fresh Pond.

Metropolitan Sewerage Commission.—The high level sewer, about 9 ft. in diameter, is now under construction for a distance of about three miles northerly from Neponset River, partly in open cut and partly in tunnel.

Metropolitan Water Board.—Work on Spot Pond is nearly completed, and the pond will soon be filled. There is now an excellent opportunity to see this work.—A 20,000,000-gallon pumping engine is being erected at the Spot Pond pumping station.—Two of the 35,000,000-gallon pumping engines in the Chestnut Hill low service pumping station are now running, and the third is being erected. Vertical boilers are used in this station as well as in that at Spot Pond.

Massachusetts Harbor and Land Commission.—A heavy timber retaining bulkhead is being built at South Boston.—Work on two wharves at South Boston will be begun at once, as well as dredging approaches to them.

City of Boston. Cambridge Bridge.—The general design has been adopted, and is for a drawless bridge of eleven steel arched spans on massive stone piers. Bids are now asked for constructing the eight smaller piers. Each span will consist of 12 plate ribs. The maximum span is 188.5 ft., and the clear head room above high water will be 26 ft., for a width of 50 ft. Each side of the center span there will be a very large pier carrying two ornamental stone towers.—Smaller towers are also to be placed on the abutments.

Boston Transit Commission. East Boston Tunnel.—A section in Maverick Square, East Boston, is under construction, and trench is open for nearly the whole length of the section, 800 ft. Concreting has just been begun.

Brookline and Newton, Mass.—About 3,000 lin. ft. of streets upon the north slope of Corey Hill, with sewers, surface water drains, gas and water pipes therein, underdrains, paved gutters, ballasted with 10 ins. ledge stone and 2 ins. gravel; no ballasting yet in place.—Street at Chestnut Hill on southwest corner of Hammond and Beacon Streets, about 1,500 ft. long with all appurtenances, of similar character to the above, nearly completed.—Streets at Chestnut Hill, off Reservoir Ave., near aqueduct terminal chamber, about 1,000 ft. long, 50 ft. wide, with surface water drains, paved gutters, etc.; 6 ins. of ledge chips, 2 ins. of broken stone and gravel surfacing; excavation in progress.

Cambridge, Mass.—Work in progress on construction of improved sewerage system; sewers from 8 ins. to 4½ ft. diameter. Appropriation, $100,000.

Worcester, Mass., and Vicinity.—The city of Worcester is constructing some sewers; also a new dam on the Holden supply, Worcester Water-Works.—Extensive construction of underground conduits for electric light wires.—A new dam in Leominster is soon to be built for E. M. Rockwell.—Reconstruction of arch bridge at Gilbertville.

Boston Elevated Railway.—At Sullivan Square terminal the steel framework for the car shop and shed is being erected; at Corning and Kirkland Sts. concrete f... tion walls for a storage battery building are being ... place; and at Lincoln Wharf the concrete foundati... the power station is practically finished, and wor... been begun on the brick chimney, which is to be 13... interior diameter and 251½ ft. high.

B. & A. R. R.—Rebuilding pile bridge with draw ... Broad Canal, Cambridge.

B. & M. R. R.—A wooden lattice through bridge is ... built at Goffstown, N. H., on the North Weare Bran... Work was commenced at East Somerville on the abo... of grade crossings at Cambridge and Perkins Sts.

Fitchburg Division.—On July 1 the lease of the F... burg R. R. to the Boston & Maine went into effect, ... the former became the Fitchburg Division.—The wor... the separation of grades at Fitchburg is progressing, ... the erection of the highway bridge at Putnam St. ... begin July 9.—Work on the separation of grades at U... St., Gardner, has begun.—The masonry arch bridg... Hoosic Junction is well under way. The east abut... and pier is about half completed, and centers for ... east span are in place. This bridge is a double-track g... ite arch bridge of two 100-ft. spans.—Work on the do... track between Johnsonville and Snyder, N. Y., is pro... gressing, and in connection with this a 60-ft. double-tr... masonry arch is being built west of Schaghticoke.

The Fore River Engine Co., of Weymouth, Mass., will have the two U. S. 30-knot torpedo-boat destroyers, "Lawrence" and "Macdonough," ready for launching early this fall, at which time they will be completed ready for trial run.—The steam steel lightship No. 72, which will be stationed off Cape Hatteras, is also nearly ready for launching.—Work upon the hull of U. S. sheathed-protected cruiser "Des Moines" is under way, and the keel will be laid at the new works of this company in about two weeks. These new works will be located at Quincy Point, about two miles below the present works, at which point the company has purchased about 70 acres of land adjacent to deep water basin. The plant will comprise: Administration building; ship tool-house 400 × 70 ft., machine shop, 250 × 120 ft.; powerhouse, 105 × 65 ft., containing boiler capacity of 1,000 HP.; a wood-working shop, 300 × 70 ft.; forge shop, brass foundry, galvanizing shop, paint shop, rigging loft, stock and storerooms, etc. The foundations for ship toolhouse, machine shop and forge shop are completed and work on the superstructure is well advanced. A considerable portion of the machinery for the plant has been delivered, including locomotive and cars which have been at work about two months on construction. In about three months the company expects to have a shipbuilding plant that will be the equal of any shipyard in the country for building the largest and heaviest class of work afloat, for either the government or merchant marine.

*The bulletin is in charge of the Excursion Committee of the society, Chas. W. Sherman, Secretary, 3 Mt. Vernon St., Boston, Mass.

SUPERINTENDENT'S REPORT ON THE FAILURE OF THE AUSTIN DAM.

An official report on the present condition of the Austin dam and the probable causes of its failure, has been made by Mr. H. B. Patterson, Superintendent of the water and light department of Austin, Tex. On July 12 and 13 soundings were made at intervals of 26 ft. (13 in all) along the break. The original foundations were undamaged "and in all cases not less than 6 ft. of the footing course remained." The line of cleavage ranged from 4 ft. below to 3 ft. above the toe course, and in some places the whole foundation was intact. Mr. Patterson says this disproves the "theories that the dam was destroyed by imperfect foundation, or that any water was escaping under it."

As to the causes of the failure, Mr. Patterson says:

> This subject has been previously treated by engineers as though 11 ft. of water was passing over the dam, with tail water at zero, which was not the case. At the time the dam gave way we had about 11 ft. of water passing over the dam, and about 25 ft. of tail water which was unable to get away. This 25 ft. of water below would have the effect of balancing a certain amount of water above, which would place the foundation of the dam on a safer basis than at any date in its history. The greatest tendency to move the dam from its foundation was when the water was at its crest and the tail water at zero. We find that by striking the 25-ft. line of tail water directly through cross-section of the dam, it passes through that portion of the dam which was only 31 ft. in thickness, and on very close examination we find the cement work exceedingly poor. This, in my estimation, was the cause of its failure. Being on the ground when this failure occurred, and seeing the dam, in less than a minute after it broke, its appearance was as though a piece had broken out immediately in the middle with water flowing over the whole crest, with a slight depression in the center, and it only took, of course, a very few minutes with this terrific rush of water to cut out the rest of the dam and relieve the pressure.

The western 600 ft. of the dam is in as good a condition as ever, but all the eastern part left in place, "including headgates, is almost a total wreck," and "would have to be taken down." Mr. Patterson discusses the rebuilding of the dam and power house as follows, which, with the mat-

ter previously quoted, includes the bulk of his report:

In the reconstruction I should recommend the placing of waste gates on the western side, to be located at the extreme bottom of the dam. These waste gates to be not less than 9 ft. in diameter, and operated from above hydraulically or by some other approved method.

In my estimation, the down-stream side of the old dam was incorrect in its foundation, as in excessively high rises I am sure the water did not follow this curve, but shot over the toe stone, which caused such an excessive digging out below the dam in the last June rise. This down-stream slope should be on a straight line of 45°, and the base of the dam, including the toe stone, not less than 90 ft. in width. It would be practically impossible for the water to leave this 45° line, no matter what height of water we might have in the river, and it would materially add to the strength of the dam.

The eastern portion of the dam should be entirely reconstructed, including the headgates, and lowering of same to not less than 30 ft. below the crest. The power house should be reconstructed and located parallel with the dam and made a part of same. A complete set of directly-connected three-phase electrical apparatus should be installed, which would have the effect of equipping the plant with all the improvements of the day and very much increase the efficiency. This efficiency would be increased as from 60 to 80%, and would mean a consumptoin of 10,000 cu. ft. of water per minute less to produce the same effect at 8.30 p. m. While the lowering of the tubes would give us a very much greater storage capacity, these two items, I am convinced, would carry us over the low water periods of the year, but the plant could be so arranged that an auxiliary steam power could be put in if desired.

The cost of reconstruction would be very much less than the original cost, there being 600 ft. of the dam which could be utilized in its reconstruction, and so much of the early foundation work is intact. The approximate expense of the reconstruction of the dam proper, on lines as advised above, would be in the neighborhood of $300,000. Adding to this complete rebuilding of power house and its equipment with up-to-date electrical apparatus, on the supposition that the water wheels now in the old plant should be used, present foundations and old material of power house also as far as advisable, the expenditure would be increased to about $500,000.

This would not only give Austin the best equipped plant in the United States, but the difference in operating expenses over the best equipped steam plant would warrant the expenditure of $600,000 in its construction.

JASPER R. RAND.

A well-known figure in American engineering circles has been removed by the death, on July 18, of Mr. Jasper R. Rand, President of the Rand Drill Co. Mr. Rand, while not strong physically, had been in usual health of late; and his death occurred suddenly from apoplexy, superinduced, it is probable, by the hot weather.

Mr. Rand was nearly 73 years of age, having been born in Westfield, Mass., Sept. 17, 1837. His father was a whip manufacturer in this town, and Mr. Rand, with his younger brother, the late Addison C. Rand, succeeded to the management of the business in 1865. Five years later Mr. Rand removed to New York, and became interested with another brother, Mr. Albert T. Rand, in the Laflin & Rand Powder Co. In 1872 Mr. Addison C. Rand began the manufacture of rock drills and other mining machinery, and shortly afterward Mr. Jasper Rand joined him in organizing the Rand Drill Co., with Addison Rand as President, and Jasper Rand as Treasurer. These offices were continuously held until the death of the younger brother in March last, when Mr. Jasper Rand became President.

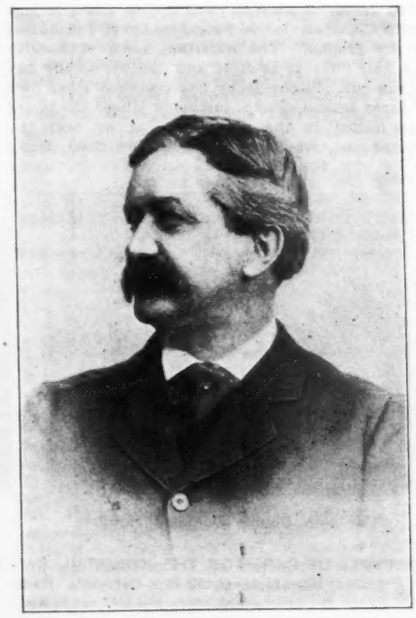
In 1873 Mr. Rand became a resident of Montclair, N. J., and he has ever since been a prominent figure in the social life and the development of this thriving suburb of New York. He served for three years on the Town Council, and was for two years a Chosen Freeholder of Essex County. He was one of the organizers of the Montclair Club, and served for two terms as its President. He was for fifteen years a trustee of the First Congregational Church of Montclair, and was one of the organizers of the Bank of Montclair, of which he has been the President since its organization. He became a member of the American Institute of Mining Engineers in 1882, and was also a member of the New England Society, the Hardware Club and the Engineers' Club of New York city, and the Mt. Moriah Masonic Lodge of Westfield, Mass.

Mr. Rand was a man of plain and unassuming manner, and quiet tastes. His sterling reputation as a business man, and his kindly nature made him a counsellor whose advice was constantly sought, and won for him a wide circle of friends. He leaves a widow, a daughter and one son. The last named, Mr. Jasper R. Rand, Jr., has been the Paris representative of the Rand Drill Co. during the present year.

COLONIAL EXHIBITS AT THE PARIS EXPOSITION.

(Editorial Correspondence.)

There is no feature of this great Exposition more thoroughly successful and more deserving of praise than the Colonial section. Near the Trocadero Palace, on the opposite bank of the Seine from the Champ de Mars, are grouped the buildings in which are displayed the products, industries, peoples, geography, flora and fauna, and in general everything of interest regarding the various lands over which the great civilized nations of the world claim jurisdiction outside their own immediate borders. For the most part, these exhibits are placed in buildings representative of the architecture and general methods of construction prevalent in the respective countries. There is a goodly sprinkling of natives as attendants, and there are wax figures in characteristic



Jasper R. Rand, M. Am. Inst. M. E.

costumes, often displayed in front of a dioramic picture, so well done that it is difficult to tell where the actual objects end and the painted ones begin. These, with an abundance of photographs and transparencies, present such a realistic picture of life in these various lands as to make the visitor feel when he leaves as if he had actually visited the country itself.

This sort of exhibit, too, is of especial interest because of its novelty. The products of civilized countries, which take up most of the space at any great fair, closely resemble each other; and a good share of the exhibits of this sort merely duplicate the displays in the store windows of any large city. One might travel for years, however, through Asia and Africa and the islands of the sea, and not be able to learn as much concerning the different countries and peoples as can be learned in a few days here.

Moreover, this exhibit is—or ought to be—of especial interest to Americans. We are still green at the colonial business, but we are certainly in it, for better or worse; and how best to carry it on is one of the things which we ought to study.

Perhaps our greenness in the colonial business is reflected in the fact that up to the beginning of July the United States representation in the colonial section was confined to the rather small display made by Cuba. Whether this can properly be credited to the United States or not is a question which need not be discussed here. It is at least true that the United States treasury furnished the funds for installing the exhibit. Concerning the other colonial possessions of the United States whose status is unquestioned: A very small space adjoining the Cuban display was at the end of June occupied by packing boxes whose labels indicated that they contained the Hawaiian exhibit. Porto Rico is not in evidence, even in packing boxes. As for the Philippines, our exhibit from this quarter of our dominions is not to be found in the colonial section, but in the Army and Navy building, where a collection of very good photographs shows some of the lively experiences of American troops in this quarter.

I believe Mr. Dooley was in some doubt, upon our first discovery of the Philippines, as to whether or not they were canned goods; and thus far the only product of our Philippine possessions which we are able to exhibit appears to be preserved ginger.

In the colonial section, as elsewhere, France makes the largest showing, and deserves great credit for the energy and enterprise with which the display has been prepared. If I mistake not, these exhibits show, too, something of the national pride over colonial possessions, and something of the estimate in which they are held as outlets for the surplus energy of the nation, and to some extent for surplus population as well.

The growth of colonial trade is a notable feature. Statistics everywhere show a steady, and in many cases, a rapid growth in the volume of exports and imports. With the advent of the white man, the tribes which had lived for unknown generations the simple life of the savage, with few necessities and those supplied by themselves, begin to want what the white man can furnish—guns, cloth, beads—and later the multitudinous things that a higher stage of civilization requires. To buy these things they will get the things which the restless white man wants—gum, ivory, fish, rubber, gold—whatever their land can furnish, and their labor can obtain. Thus the process of commercial expansion goes on. The demands of civilized countries for the products of the torrid zone, and indeed for all the products of the earth, are constantly increasing, and these regions in turn call for more of the things that the great centers of civilization can furnish.

While the commercial and ethnographical features are most prominent in these colonial exhibits, there is not a little display of engineering works. Commerce cannot go very far nowadays without the railway and the steamboat; and no shipping port can obtain much trade until some sort of pier accommodation is provided where vessels can load and discharge cargo. If mining operations of any sort are carried on, the work of the engineer is at once necessary; and the variety of minerals shown is a notable feature of these colonial exhibits.

A fair example of a colonial railway is exhibited back of the Trocadero, the exhibit consisting of a section of track with a locomotive, passenger car and track velocipede, all from the Dakar & St. Louis Ry., which is not in Missouri, as an American might suppose, but in Senegal. The track is meter gage, with very light rails laid on steel cross ties, which are said to have been down since 1889, and appear as good as new. The locomotive has a small iron pilot and the inevitable lid on top of the smokestack, to shut down when the locomotive is standing in a covered trainshed. One would suppose that such structures would be rare on the Senegal railways.

The track velocipede is a far better machine than those in use on most American railways. It is a three-wheel machine, built on regular bicycle lines, with framing of steel tubing, bicycle pedals, gear and chain and wire-spoke wheels with steel rims. Instead of rubber tires, which would soften on a rail exposed to the sun in a hot climate, the steel rims are covered with a heavy cloth, appearing like close-woven jute.

Another exhibit near by, was an invention which really seems to have a large field of usefulness. It is a single-rail railway, and about the only single-rail construction that ever had any chances of success. Briefly stated, it is a railway system for lines where the cheapest construction is desired, and where animal traction and not me-

chanical motors will suffice. The cars are balanced over the rail, and a light frame is secured to one side of the car. In this frame is placed a horse or mule, and a suitable saddle and girth transfers any unbalanced weight of the car to the animal's body. Both passenger cars and freight cars of various sorts are shown, all of small size, of course, but it must be understood that this system of transportation is designed for places where nothing in the shape of rail transportation has before been applicable.

The cost of construction should be exceedingly small. The rail is very light, weighing not more than 8 lbs. per yd., and is supported on square blocks spaced about 2 ft. apart. The cars have one wheel in front and one in the rear, and the wheels have deep flanges, so that derailment cannot occur. Each car drawn by one horse or mule carries a load of 3,000 to 4,000 lbs. It will be evident that on such a line all matters of gage, curves, tangents, etc., are of no importance. The car runs as easily on a curve as on a straight line, and no matter how crooked or wavy the rail, the wheel will follow it.

The applications of this type of railway are numerous. For farms and plantations, for earth and rock work by contractors, for outside transportation around mines and quarries, for factories and industrial works, and, finally, for military transport, it appears to deserve careful consideration. The last application is especially noteworthy. It is, so far as I know, the only type of railway that is really light enough and portable enough to be laid behind an army as it advances in a campaign to keep it in touch with its base of supplies.

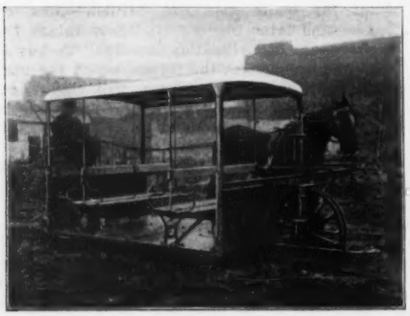
The system is exhibited by Mr. H. J. Caillet, 39 Rue Lafayette, Paris, and is, I believe, covered by patents.

By far the most interesting exhibit to an engineer in the colonial section is that made by Russia respecting the great Trans-Siberian Ry., which is now open for transcontinental traffic, although the most eastern section is still under construction. The line is completed and in operation from Tcheliabinsk to Sretensk, 2,762 miles, with the exception of the section around the head of Lake Baikal; but trains are transferred across the Lake by a special ice-breaking car ferry steamer. From Sretensk to Khabarofsk, 1,442 miles, the journey is made by steamer down the Shilka and Amoor rivers, and then another railway journey of 478 miles brings the traveler to Vladivostok.

The through express trains on this road leave Moscow every week, and are operated by the International Sleeping Car Co., which has on top of the Trocadero hill a complete Trans-Siberian express train on exhibition, together with a panorama of the country along the line. The train is made up of baggage car, dining car, and first-class and second-class car, and contains everything that can be imagined to make comfortable and pleasant the longest direct railway journey that can be taken anywhere in the world. Besides all the luxuries with which travelers on American limited expresses have become familiar, there is a gymnastic apparatus and a dark room for the use of amateur photographers on the train.

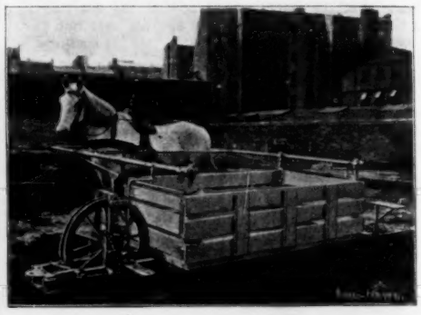
Of even more interest to the engineer, however, is the large collection of models, photographs, drawings and pamphlets, relating to the work of construction of the Trans-Siberian R. R. Only by long study of these can some fair conception be formed of the difficulties which were encountered in pushing this work to completion across this vast and sparsely-populated country. Its value in the development of Siberia, however, is such as to make it well worth all its cost to Russia, no matter what the sum may be.

The Canadian and South Australian exhibits, although located in the colonial section, are so excellent and "civilized" a display, as to deserve to be shown in the regular departments of the exhibition, where they would have supplemented the rather meager showing made by England. However, they have their interest when grouped in their present position, as showing what a position these young nations—for they are nothing less—have attained in the arts and industries. In the Canadian exhibit the display made by the Grand Trunk and Canadian Pacific railways are deserving of mention, especially as no such displays are made here by any United States railway company. In the South Australian exhibit, a remarkable feature is the jarrah and karri woods. A tombstone—if it can be called a stone—made of jarrah wood is on exhibition, which has stood in the Perth Cemetery for 66 years, its lower end buried in the ground. The lettering, some of it with fine hair lines, is as clear and distinct as the day it was cut. Slight decay has occurred along two or three season cracks, but none where the board was buried in the ground, or at or near the ground line, where decay is usually most rapid. The whole piece is so sound that it takes a polish like mahogany. A pile is also shown which has been in place in Perth harbor for 30 to 40 years. Apparently jarrah is the only wood which can dull the teeth of the teredo. Paving blocks, stair treads, parquet floors and numerous other articles of these hard Australian woods are shown, and if the available supply is sufficient, they are evidently destined to fill a most important place in the world's commerce.



Passenger Car for 12 Passengers.

Car with Double Dumping Hoppers.



Low-Side Gondola Car for Package Freight.

VARIOUS TYPES OF CARS FOR THE MONORAIL RAILWAY.
H. J. Caillet, Manufacturer, 39 Rue Lafayette, Paris.

IRON AND STEEL RAILS IN AMERICA.*

By Robert W. Hunt, M. Am. Soc. C. E.†

As America came to Great Britain for the rails used on her first railways it is perhaps fitting that this paper should be presented to the Society in London, and at its first English meeting.

The rails used on the earliest American railways were of wood with flat bar-iron nailed to their upper surface. The track of the Baltimore & Ohio R. R. is described as consisting of—

Cedar cross-pieces, and of string-pieces of yellow pine from 12 to 24 ft. long and 6 ins. square, and slightly beveled at the top of the upper side for the flange of the wheels, which at that time was on the outside. On these string-pieces iron rails were placed, and securely nailed down with wrought-iron nails 4 ins. long. After several miles of this description of road had been made, long granite slabs were substituted for the cedar cross-pieces and the yellow pine stringers.

The iron used for rails was ½ to ⅝-in. thick by 2½ to 4½ ins. wide. The heads of the nails or spikes holding it down were countersunk in it.

Notwithstanding these strap-rails being "securely nailed down," it was found that traffic would loosen them, with the final result of their turning up as the wheels passed over them, and forming what were called "snake heads." These would occasionally tear through the bottoms of the cars, and cause more or less inconvenience if not danger to the passengers. So the American engineers again turned to England, where the same difficulties had led to the invention of rails of different sections. It is believed that the first one was the fish-bellied rail, invented by John Birkinshaw, of the Beddington Iron Works, and patented in October, 1820. This rail was held in cast-iron chairs by side keys or wedges. The Baltimore & Ohio Co. soon afterward imported some of these rails.

The Stockton & Darlington, and its follower, the Liverpool & Manchester, which was opened in September, 1830, were principally laid with rails of the Birkinshaw type. The Stockton & Darlington also had a few cast-iron fish-bellied rails.

The Clarence rail was another English invention and was considered an improvement on the Birkinshaw. Rails of that pattern were imported into America for the Allegheny Portage R. R., built by the state of Pennsylvania over the Allegheny Mountains to connect the canals on either side of them. This road was opened in 1833.

In 1834 the Columbia and Philadelphia R. R. was opened. Part of this road was laid with flat rails, but on the greater part the Clarence rails were used. On both roads the rails rested on stone blocks. These roads were in after years absorbed by the Pennsylvania R. R.

Another English section was the H-rail, which rested in a chair. These were imported, and used on some of the roads. Still later, came the U-rail, known in Wales as the Evans patent, and believed to have been first rolled at the Dowlais Works.

The Earliest Rail Mills.

Some of the flat strap-rails were made in America, but all the sectioned ones were imported. Some attempts were made to use American cast-iron rails, but with unsatisfactory results. It was not until 1844 that the manufacture of sectioned wrought-iron rails was begun in America. A rolling mill was built in 1843 by the Mount Savage Rolling Mill Co., at Mount Savage, Allegheny County, Md., expressly to make rails. Operations commenced in 1844, and for their first rail, which was of the U-section, they were awarded a silver medal by the Franklin Institute of Philadelphia. The rail weighed 42 lbs. per yd. About 500 tons were laid in 1844 on the road then being built between Mount Savage and Cumberland, Md. A short time later they rolled some 52-lb. rails for a road between Fall River and Boston, and in 1845 and 1846 they rolled T-rails. This mill, after being long abandoned, was finally dismantled in 1875.

The T-rail was generally known in Europe as the "Vignoles" rail, after Charles V. Vignoles, an English railroad engineer, who introduced its use there; but it was really invented by Robert L. Stevens, of Hoboken, N. J., President and Engineer of the Camden and Amboy R. R.

In 1845, the Montour rolling mill, at Danville, Pa., was built expressly to roll T-rails, and in October of that year there was rolled in that mill the first rail of that section made in America. In 1846, T-rails were rolled by the Boston Iron Works, Boston, Mass.; by Cooper & Hewitt's mill, at Trenton, N. J.; by the New England Iron Co., Providence, R. I.; by the Phœnix Rolling Mill Co., Phœnixville, Pa.; by the Great Western Iron Co., Brady's Bend, Pa.; and by the Lackawanna Iron Works, Scranton, Pa. In the following years the manufacture was taken up by other companies; but owing to the commercial conditions caused by the severity of foreign competition, early in 1850, only two out of the fifteen rail mills in the United States remained in operation.

These early rails were all short; none over 15 ft. long. As the difficulties of manufacture were overcome and the

*Condensed from a paper presented at the annual convention of the American Society of Civil Engineers held at London, Eng.

†Rookery Building, Chicago, Ill.

science of track laying progressed, the length was gradually increased until 21 ft. was reached, and was considered the limit. It was not until about 1859 that railway engineers would accept those of greater length. The first 30-ft. rails rolled in America were made by the Cambria Iron Co., Johnstown, Pa., in 1855; but they could not find sale for them and they were finally used by that company in their mill yards. The first 30-ft. rails to fill an order were rolled by the Montour Co., in January, 1859, for the Sunbury & Erie R. R. Co.

Early Rolling Mill Machinery.

The rolling of iron rails was attended with many difficulties. If the pile of bars were not heated to a sufficiently high degree, the welds would not be perfect; and if heated too highly, the iron would crack in the process of rolling and yield an imperfect product. If the metal were too cold although the rail might be free from flaws and bad welds, it would wear out rapidly under traffic. Under all circumstances it was important that the rolling process should be completed as quickly as possible so that the reductions should be made while the iron had lost little of its heat. This, together with some local conditions, led to the invention by John Fritz, Hon. M. Am. Soc. C. E., of the three-high rail train. Three-high sets of rolls had been used for many years in making merchant bars, but it required the application of the "Fritz Yielding Hanging Guides and Driven Feed Rollers," to make them practical for rail rolling. This improvement was put into successful operation at the Cambria mills in 1857. It has ever since remained as the typical American rail mill. Since the introduction of steel rails there have been several two-high reversing mills on the English plan, used in America; in fact, two of this kind are now running. But the three-high is the American mill, and has permitted the tremendous production which has been attained in later years.

The early mills required the work of handling the material as it passed through the rolls to be done by manual labor, through the use of tongs and hooks. Probably the rolling of iron piles with their necessarily peculiar handling, would have indefinitely continued this, but with the use of solid steel blooms, the troubles lessened and made possible the introduction of automatic machinery. The tong and hook system necessitated the employment of 15 to 17 men, and the production of steel rails was limited to not over 250 tons per turn. Automatic machinery revolutionized this, both as to number of men employed and the possibilities of production.

It was the writer's fortune to introduce the first driven rail-mill tables, those in the works of the Albany & Rensselaer Iron & Steel Co., Troy, N. Y., in March, 1884. These were in front of the finishing rolls, and worked so well that an automatic arrangement was soon after placed in front of the roughing rolls. This latter arrangement was more particularly designed by Mr. Max M. Suppes, then the master mechanic of the works, and now the general manager of the Lorain Steel Co., Lorain, O. Naturally, these devices were protected by letters patent. From this start other inventions were made, and many improvements by other American engineers have followed, until the present American rail mill, capable of turning out 50,000 tons of finished rails per month, has been developed.

Difficulties with Iron Rails.

It was the writer's fortune to become connected with rail making in 1856, and among his earliest recollections is the statement that the users of rails had in service certain makes which had been and were giving results impossible to be obtained from any of more recent manufacture. How familiar that statement must sound to many of you, and as of recent date!

The first iron rails were made from straight puddled bars. These bars were about 1 in. thick and were placed one upon another, until a pile of sufficient weight and height was formed; the pile was then reheated and rolled into rails. And it was to the formation of that pile that inventive genius was applied. From an investigation of the fracture of some of the rails which had given satisfaction, it was discovered that the pile of bars from which they had been rolled, had been entered in the rolls edgewise, thus bringing the line of welds between the bars in a vertical instead of horizontal position. This presented a different structure to the wheel wear, and seemed to be logical. Based on that supposition many rails were so rolled, and the writer believes that the scheme was patented.

Where the rail was rolled with the layers of the pile in a horizontal position, particular attention was given to the character of the top bar, which would, of course, form the wearing surface of the rail. Cold-short or granular iron was used for it, while the remainder, or at least the flange of the rail, was of fibrous iron. At one time a rail with a puddled-steel head—or rather with the top bar of the pile of puddled steel—found much favor, but, owing to the difficulty of obtaining uniformly good welds, the results were not satisfactory. Some of these so-called steel-headed rails had the top bar of what was known as silicon steel.

Another plan, on which much money was spent, was to hammer a puddled ball, or weld two puddled balls together, under a steam hammer, and draw them into a slab 2 to 2½ ins. thick, which was used on the top of the rail pile. Under an order from the Pennsylvania R. R. Co., the Cambria Iron Co., in whose employ the writer was then serving, erected a special steam hammer, and made several thousand tons of such rails. Their service was somewhat disappointing, and the practice was abandoned.

At that time, as since, commercial conditions controlled. The railways had the worn-out rails on their hands, and, regardless of whether or not the practice would give satisfactory results, they adopted a system of having the old rails re-rolled into new ones. At first a certain percentage of new iron was specified, but as the necessities for immediate economies increased, that demand was eliminated from the contracts, and the new rails were composed entirely of the old ones. The best practice was to make a pile of old rails, break it down into bars, which were piled upon each other, and then rolled into rails. But presently this was found to be too expensive to successfully meet the cry for cheaper rails, and only the top and bottom of the piles were formed from re-worked iron, the center being composed of from three to six pieces of old rails.

The Earliest Steel Rails.

From the many re-workings, the cheapening of the process of manufacture, and the increasing demands of traffic, the wear of the iron rails became more and more unsatisfactory, until it seemed as though, from that cause alone, the limit of railway development had been reached. Such situations frequently occur in earthly affairs; and seldom if ever has the occasion failed to be met by a solution of its difficulties. In this case, came the invention of Bessemer. It is a historical fact that the first rail ever made from Bessemer steel was placed on the Midland Ry., of England, early in 1857, at a point where iron rails had sometimes to be renewed within three months; and it remained there until June, 1873, some 16 years, during which time about 1,250,000 trains and any number of detached engines and tenders passed over it. We all realize that without such an innovation as Bessemer's, the subsequent tremendous expansion on railway development would have been physically impossible.

Railway managers were timid about using steel rails, and in America many attempts were made to produce a satisfactory rail having an iron base and web, with a steel-capped top. None were satisfactory, and the Bessemer steel rail soon conquered the situation.

The first steel rails laid down by an American railway were imported by J. Edgar Thomson, President of the Pennsylvania System. The first to be manufactured in America were rolled at the mills of the North Chicago Rolling Mill Co., Chicago, Ill., on May 24, 1865, from ingots produced in experimental steel works at Wyandotte, Mich. They were not many in number, and were made on the regular iron rail rolls of the mill. Several of the rails were put in local railway tracks and gave good service.

The first production of steel rails in the United States, on a commercial order, was at the Cambria Iron Co.'s mill, in August, 1867, from ingots made by the Pennsylvania Steel Co., near Harrisburg, Pa. The converting works of that company were completed some time in advance of its rail mill, which led to an arrangement under which the ingots were sent to Johnstown to be hammered into blooms which were then reheated and rolled into rails. The steel was made under the management of the late Alexander L. Holley, M. Am. Soc. C. E., then in charge of the Pennsylvania Steel Co. George Fritz was the Chief Engineer and General Superintendent of the Cambria Iron Co., and Alexander Hamilton, Superintendent of the rail and other mills, while the writer was in direct charge of the steel department. It is a matter of some interest, that the ingots were drawn down by the steam hammer which had been installed some years before to make the hammered iron slabs for the Pennsylvania R. R. Co.'s rails. From this time, the production in America of Bessemer steel rails increased rapidly.

Bottom Casting of Ingots.

For a time after the starting of the Pennsylvania Steel Co.'s Bessemer works, the ingots were cast from the top, on the then-accepted English plan. Mr. Holley's mind was not so constituted that he could long follow any beaten track without an effort to do better work on some other line. Thus, he introduced the bottom-casting of ingots; pouring the steel into a central octagonal mold about 14 ins. diameter at the bottom and 10 ins. at the top, from the bottom of which the metal flowed through connecting gates into four surrounding molds 8½ ins. square. This plan was adopted after consultations with Mr. George Fritz, who had rolls turned to take the 8½-in. ingots. The central or sprue ingots were hammered into blooms. It was found that the small ingots rolled satisfactorily, while, on the contrary, the central ones cracked badly during working.

This led to much discussion and consultation among the operative officers of the Cambria Co. and Mr. Holley, the result of which was that John E. Fry, then superintendent of the Cambria Iron Co.'s iron foundry, suggested the use of a rammed-up center sprue, 4 ins. in diameter, connecting through fire-brick gates with surrounding ingots; the sprue and gates to be treated as scrap. This plan answered admirably.

While in charge of the experimental Bessemer Works at Wyandotte, Mich., in the interest of the Cambria Iron Co., the writer had developed a manner of bottom-casting ingots. Mr. Holley having protected his plan by a patent, Mr. Fry and the writer united in patenting theirs, and their interest and those of Holley were consolidated. For some years after this, practically all bottom-casting of ingots in America was licensed under these patents. After a time the price of rails became so much reduced that the loss incident to the scrap of the center sprue and bottom gates made in bottom-casting became a serious matter, and while it was and is impossible to cast as sound, and hence as good, ingots from the top, the better plan was abandoned.

Development of the Blooming Mill.

At first, all the American bessemer works pursued the English plan of reducing the ingots to blooms under steam hammers. This was so at the Pennsylvania and Troy works. The success in rolling the 8½-in. ingots at Johnstown led to the invention of the American blooming mill, and this soon completely superseded the steam hammer in rail making.

This idea originated with Mr. George Fritz. Holley and he were intimate friends and exchanged views freely. Holley had severed his connection with the Pennsylvania Steel Co., and returned to the Troy, N. Y., works. There he built a three-high blooming mill. While it had tables, their rollers were not power-driven, and the ingots had to be pushed into the rolls and turned over on the tables by hand. Soon after, George Fritz built a blooming mill at Johnstown, in connection with a Bessemer converting plant, and put into use his patented ideas of driven rollers, hydraulically controlled movable rolls, and a "turning over and sliding from pass to pass" device, christened by the mill hands a "go-devil," which permitted the economical handling of larger ingots. This was the birth of the American blooming mill. In perfecting his plans George Fritz had the benefit of the advice of his brother John, then manager of the Bethlehem, Pa., works.

Perhaps these details apply more to rolling-mill practice than to the rails themselves; but the writer thinks that they have played a most important part in relation to the character of steel rails, and are pertinent to the subject. Holley started the innovation by which the production of steel ingots has been increased so greatly. Fritz gave the blooming mill, which would not only take care of all that was sent to it from the converting works, but like Oliver Twist, ask for more; and the late Capt. William R. Jones, Robert Forsyth, M. Am. Soc. C. E., and several others built rail mills which were not satisfied with the amount of steel sent to them by any blooming mill. This has all been magnificent. It has made possible undreamed-of low prices for steel rails. It has helped to build railroads, but has it improved the quality of the rails produced?

Reasons for the Good Wear of Early Steel Rails.

Steel rails, when first manufactured, replaced iron rails, which, through their deteriorated quality and the increased duty demanded of them, were giving most unsatisfactory service. Some of the early steel rails failed, but most of them were so much better than the best of their predecessors that such failures did not excite adverse comment. They were of what would now be considered light sections, and thus in their production from the 6 × 6-in. or 7 × 7-in. blooms from which they had been rolled, had received much work, and at a comparatively low temperature. In the writer's judgment the greatest factors in the production of good rails are covered by the words "work and temperature." All steel men know that work at high heats does not change the grain of steel at all in proportion to work given at lower temperatures.

For years after the introduction of steel rails a 65-lb. per yd. section was considered a heavy one. In fact, in America it was the heaviest used, and much the largest percentage was not over 60 lbs. These were rolled from 7 × 7-in. blooms. The ingots from which the blooms were made were generally 12 × 12 ins. After the bloom was formed it was examined carefully after becoming cold, and all cracks and mechanical imperfections were chipped out. Then, after slow heating, with care to avoid too high a temperature, the blooms were rolled into rails by light reductions. While this was being done, if a defect showed itself, the process was stopped until it was chipped out. Now, this slow work at a moderate and steadily decreasing temperature, resulted in a fine grained metal, which, of necessity, no matter what may have been its chemical composition, would give greater resistance to the wear of traffic than could be possible from the coarser grained steel which is in the head of the heavier and more rapidly rolled sections of to-day.

By waiting long enough the things of the past always become the best. That is, provided the past is not examined too closely. It must be remembered that the early rails replaced a much inferior article; in fact, created a revolution in railway maintenance of way. Hence, if a few from any cause failed, it excited little comment; they were quietly replaced by others. After a while these failures were forgotten, and the whole lot of existing rails was instanced as an example of what rails should be. Another thing which must not be overlooked is, that the early steel rails had the ultimate stress of traffic applied by slow degress. In other words, the traffic to which they were subjected when first put in service was for them light duty. Heavier rolling stock, faster and more frequent trains, came gradually. The old-time rails, which are in these later days so reverently mentioned, had been sub-

jected to a cold-rolling process before being given their severest task. To-day an 80-lb. rail is hardly cold before a 175,000-lb. locomotive, hauling 100,000-lb. capacity cars at 35 hours per hour; and limited expresses of heavy Pullmans at 60 miles per hour are thundering over it.

The details of manufacture of steel rails changed, not only in America, but also in England and other countries. This had to be, and it would to-day be as impossible to return to the earlier methods as to restore the service of stage coaches. In 1876, the writer presented a paper at the Philadelphia meeting of the American Institute of Mining Engineers, on "The History of the Bessemer Process in America," and with great pride chronicled the fact that the North Chicago Bessemer Works, under the management of Robert Forsyth, had, in a single month, produced 6,457 gross tons of ingots, and that it led the world's records. These ingots were all rolled into rails. To-day, the North Chicago Converting Works and rail mill are abandoned, their places having been taken by the present South Chicago plant of the Illinois Steel Co., in which rail mill the largest month's production has been 58,103 gross tons of standard-sectioned rails. The Edgar Thomson Works of the Carnegie Steel Co. has made 47,074 gross tons of rails in a calendar month. Other American mills are turning out a large tonnage, but it is believed that the foregoing at present hold the record.

While the faster work of modern practice has somewhat altered the character of the steel in rails, it must not be assumed that the product has been increased without any regard to other considerations. That is not true; on the contrary, the outward character or finish of the rails has been improved to a radical extent. While working fast, the improved machinery is also reliable, and the care exercised in keeping true to section, square sawing, accurate drilling and straightening of both line and surface, yield results which it would have been impossible to obtain in the earlier days. In fact, the requirements of the railways, in consequence of increased weight and speed of traffic, etc., have made it imperative that such finished rails should be given them.

It is not desired to draw any invidious comparisons, but, in the writer's judgment, American makers are to-day not only turning out the most rails, but at the same time the best finished ones now produced. Moreover, foreign rails, imported into the United States and Canada during recent years, have not worn any better than American rails.

Chemical Composition of Rails.

It has been stated that examining into the past sometimes disproves assumptions. So that, while in the earlier days rail steel and rails were made with all the time and care which has been described, all the rails produced were not satisfactory. In fact, the experience of the Pennsylvania R. R. was such that their chemist, Charles B. Dudley, M. Am. Soc. C. E., made an elaborate investigation into the chemical composition of their satisfactory and unsatisfactory rails. His deductions were presented to the American Institute of Mining Engineers in October, 1878, and elicited a memorable discussion. Dr. Dudley concluded that rail steel could be too hard for good service, even though the rails did not actually break. His conclusions were in favor of chemically softer metal. Some of those discussing the matter thought and stated that the size of the rail sections should not be ignored.

As the accredited authority of the great Pennsylvania R. R., Dr. Dudley's views carried added weight, and it resulted in a demand in America for softer rails. The writer thinks that no one to-day will attempt a defence of that position. In fact, the practice did not long prevail. But it cannot be safely claimed that the present rails, whether made in America or imported from Europe, are giving absolutely satisfactory results. They are permitting the accomplishment of work which, but a little while ago, would have been considered an impossibility. Still, if engineers had ever been absolutely satisfied with that which was, progress would have halted. Heavy-sectioned rails which will yield better results than those now being obtained are needed. Our railway organizations have generally become so situated financially, that they need no longer be limited to the immediate present in the policies of their administrations.

The Introduction of Standard Sections.

In the old countries, railroads were built because there was a population whose needs demanded them. In this country they were often built because there was a tremendous amount of country and no population. This led to cheap construction, but while we still have plenty of room for more people, our country has become rich enough to justify the best of railroads, and, in fact, imperatively demands them. The successful operation of the roads themselves can be only on such a basis. As the railroads increased in number, and their requirements varied in accordance with their traffic and profiles, and being constructed and operated by many different men, it was natural that not only the weight of rails used, but their sections, should differ. In fact, almost every road had its own particular section. The variations between many were slight, but sufficient to necessitate the use of special rolls in their manufacture. This had become so pronounced, and caused so great an investment of capital on the part of rail makers and loss of time in changing from one section to another, etc., that Mr. Holley, in his characteristic progressive spirit, attacked the situation in a paper presented to the American Institute of Mining Engineers, in February, 1881. In this he stated that, answering his inquiries, the eleven Bessemer mills then making rails in the United States had sent him drawings of 188 patterns which were considered standard ones, and that 119 patterns of 27 different weights per yard were regularly manufactured. Mr. Holley gave drawings of many of these and pointed out the absurdity of some of the variations. His paper attracted wide interest, but it was a difficult matter to reach. However, its discussion was continued by others later. Mr. P. H. Dudley, who had devoted much time to the study of the wear of rails, and who invented a recording car for the examination of the rails, contributed papers on the subject to both the scientific press and societies. Mr. J. D. Hawks, M. Am. Soc. C. E., then Chief Engineer of the Michigan Central R. R., advocated certain sections, as also did D. J. Whittemore, Past-President Am. Soc. C. E., and the writer also presented a series of sections in a paper read before the American Institute of Mining Engineers, February, 1889.

This society appointed a committee on "The Proper Relation to Each Other of the Sections of Railway Wheels and Rails," which performed its duties in a thorough manner; and following and resulting from its report, the Society appointed a committee to consider and recommend a series of Standard Rail Sections. This was in 1891, but the final report of the Committee was not made until June, 1893.* During the intervening years the members of the committee had worked faithfully; consulted personally and by correspondence with many of the chief engineers of the railroad systems of the country, and agreed upon all points but one. One member, Mr. George S. Morison, differed with the Chairman, Mr. G. Bouscaren, and with Messrs. Foster Crowell, Virgil G. Bogue, S. M. Felton, J. D. Hawks, E. T. D. Myers, Samuel Rea, Thomas Rodd, A. M. Wellington, F. M. Wilder, and Robert W. Hunt, as to the width of heads of the proposed sections, and, on that point, made a minority report.

As secretary of the committee during the latter part of its work, the writer knows the difficulties and labors of the task, and naturally, is gratified to know that the recommended rail sections are to-day practically the standard ones for American railroads. During 1899, quite 75% of all the rails rolled by American rail mills were of what are commercially known as the American Society sections.

Effect of Various Changes in the Ores and Fuels Used for Rail Making.

Geographical and commercial conditions must govern. When the Bessemer process was first introduced in America, imported English pig irons were used in making the steel. American irons were experimented with and gradually displaced foreign irons. This practice first prevailed in the works located west of the Allegheny Mountains. They soon relied entirely upon charcoal pig, made from Lake Superior and Missouri ores. This was much higher in phosphorus than the English irons, but the results obtained from it were so satisfactory that the investigation continued and extended to the use of American mineral fuel irons, both anthracite and coke. After a time these completely displaced both foreign coke and American charcoal brands, in both western and eastern works.

It happened that, while the most available western ores contained percentages of phosphorus fully up to the limit possible for Bessemer uses, the cheapest eastern ores were quite low in that obnoxious element. Hence, it has been and is a fact, that some of the rail makers located east of the Alleghenies can produce rails low in phosphorus contents, while using the lowest priced pig metal. The opposite is true of the western mills. These geographical and commercial conditions have led to the use of entirely distinct chemical specifications in the two districts—at least by some of the leading makers in those districts.

Heavier Section Rails and Why They Do Not Wear So Well as Lighter Rails.

The heavier equipments and higher speeds required more rigid road beds, which could only be obtained by heavier sectioned rails. These were gradually adopted. It was naturally expected that as the sections were increased so would the resulting amount of service yielded by the rails. From the very first, the results obtained were disappointing, and the writer doubts whether we will ever succeed in getting results as satisfactory as those yielded by the lighter sections. As the area of the section is increased, so, of necessity, will the work upon the steel in forming it be decreased, and as the resulting mass is enlarged, so will the amount of heat retained in it at the time of the final reduction through the rolls be increased. In the writer's judgment it will be found that the most satisfactory results will be obtained by so modifying the rolling system that the final pass (or better, passes) shall be given after the temperature of the partially formed rail has been lowered. This is not by any means a new idea, but as yet it has not been carried out in a manner calculated to obtain the best results.

Some years ago, Mr. F. A. Delano, now Superintendent of Motive Power of the Chicago, Burlington & Quincy R. R., in the interest of that company, had some rails rolled at the South Works of the present Illinois Steel Co., owned by the North Chicago Rolling Mill Co., on lines and under his personal supervision. Unfortunately, these rails were of a peculiar section, which was not continued, but the writer believes that the wear of the rail itself was encouraging.

The satisfactory wear being given by rails renewed by the "McKenna Process" at the Joliet and Kansas City Mills of the McKenna Steel Working Co., bears strongly on this point. Mr. McKenna takes rails which have become unfit for further service in main line tracks, from having become rough in surface, through flowing of metal, or other causes; or which have become curved on the side of the head; and, after carefully removing any fins which have been formed on the upper edges of the heads by metal flow, charges them into a long furnace, and, when heated to not more than 1,500° Fahr., they are drawn from the furnace by a mechanical contrivance which at the same time removes any scale which may have formed on their surface, and slightly upsets or thickens the section. The rail is then passed through a set of forming rolls, from which it is carried forward to another set, in which it is given a finishing pass. The rail is then sawed hot, and cold-straightened and drilled in the usual manner. And while the section has been somewhat reduced, the original finishing sections and heights have been maintained.

Now, the steel has been given finishing work at low temperature, and examination has proven that the grain of the metal in the head of the rails has been "fined." But, more important than all, the wear of the renewed rails is promising to be much more satisfactory than that obtained from new rails of heavier sections. This treatment of rails is no longer in an experimental state, as it is over five years old, and there are nearly 100,000 tons of renewed rails in service on the Chicago, Milwaukee & St. Paul; Atchison, Topeka & Santa Fé; Wabash and other large systems. One chief engineer, on whose road there are many of these rails, says: "No rail ought to be used at all until after it has been renewed."

Chemical Specifications for Rails.

The writer has gone on record so often, as believing that in the absence of work at low heats, incident to the present method of making heavy-sectioned rails, it is important to increase the carbon with the section to as great an extent as the phosphorus present will permit, without incurring risk from breakage, that it seems unnecessary to repeat the arguments.

At the Atlanta meeting of the American Institute of Mining Engineers, in October, 1895, the writer presented a set of specifications for "Steel Rails of Heavy Sections Manufactured West of the Alleghenies." In accordance with these specifications thousands of tons have been made and used with satisfactory results. During the last two years the western makers have declined to limit the phosphorus to less than 0.10%, but, in fact, have been making steel with a fraction less than that amount—say 0.09 to 0.096%. And he regrets to say that in many cases they insist that the amount of carbon shall be less than that which he has advocated. He believes, however, that gradually, higher carbon will prevail; and certainly has not had any cause to change his mind on the subject. His experience as a steel-rail maker, and as an observer of the wear of steel rails of many sections and diverse chemical composition, leads him to advocate: First, work, after careful heating of the steel, and continued until its temperature has been much reduced. Second, that the carbon percentages shall be increased in proportion to the increase of rail section, the ultimate amount being, of necessity, limited by the contained percentage of phosphorus. In all cases he advocates the use of drop tests, on samples from each heat of steel.

At present many of the American railway engineers use the drop test, but none of them demands the static or tensile tests insisted upon by so many engineers of other countries; nor does the writer think there is any necessity for these latter. The chemical analyses and drop tests are all sufficient.

As a matter of record, the writer gives the chemical formulas contained in his specifications of 1895, in accordance with which, as stated, thousands of tons of rails have been made and have given good results. And while at present the western makers decline to limit their steel to 0.085% phosphorus, the writer certainly sees no reason to decrease the carbon. In other words, so many rails have been made and proven safe with quite as much carbon as given in these specifications, and with 0.10% phosphorus, that the writer does not think the former element should be made less, certainly not until the details of manufacture have been changed.

Robert W. Hunt's Specifications.

Sec. 8.—The carbon in the 70-lb. section shall not be below 0.43% nor over 0.51%. In the 75-lb. section, not less than 0.45% nor over 0.53%. In the 80-lb. section, not less than 0.48%, nor over 0.56%. In the 90-lb. section, not less than 0.55%, nor over 0.63%. In the 100-lb. section, not less than 0.62%, nor over 0.70%.

The phosphorus shall not exceed 0.085%.

The silicon shall not be below 0.10%.

The remainder of the chemical composition of the steel to be left to the maker's judgment.

*Transactions Am. Soc. C. E., Vol. xxviii.—Eng. News, Aug. 17, 1893.

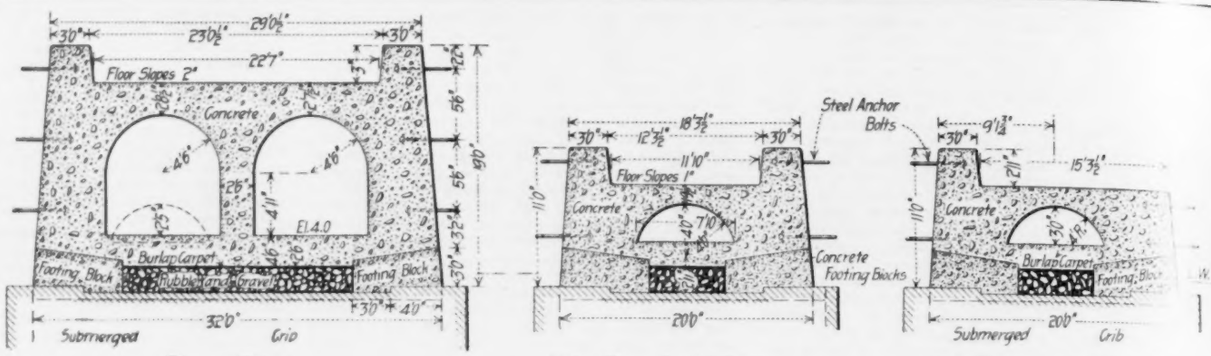
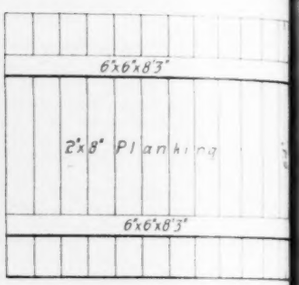


FIG. 1.—TYPICAL TRANSVERSE SECTIONS OF CONCRETE SUPERSTRUCTURE.

FIG. 3.—MOLDING CONCRETE FOOTING BLOCKS.

FIG. 10.—VIEW OF PIER WITH CONCRETE FOOTING BLOCKS IN PLACE.



Plan of Top Piece of Mold.

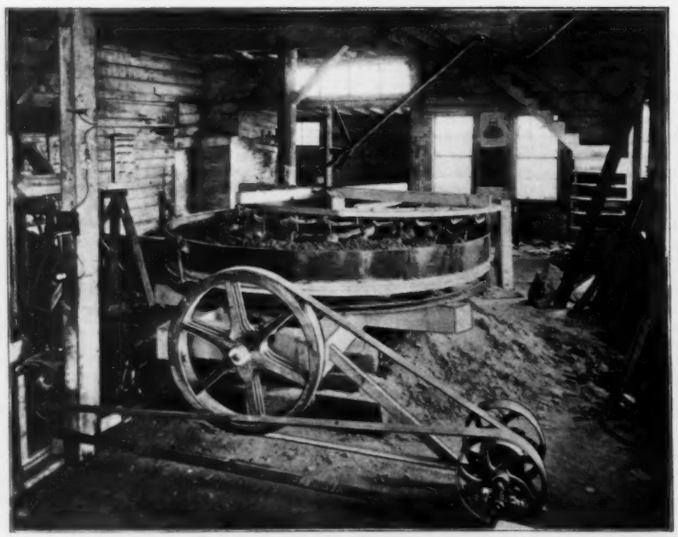


FIG. 11.—VIEW OF CONCRETE MIXER WITH PLOWS LOWERED.

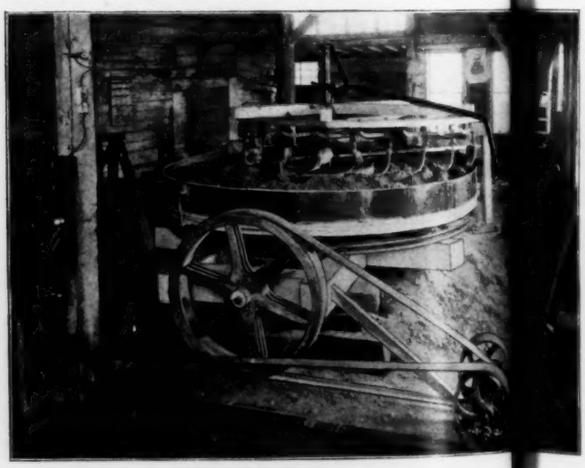


FIG. 12.—VIEW OF CONCRETE MIXER WITH PLOWS RAISED.

CONCRETE BLOCK MASONRY WORK

Major Clinton B. Sears, U. S. Engineer Corps, Engineer in Charge.

Clarence Coleman, U. S. Assistant Engi

—GALLOWS FRAME FOR LOADING AND UNLOADING FOOTING BLOCKS AT STORAGE YARDS.

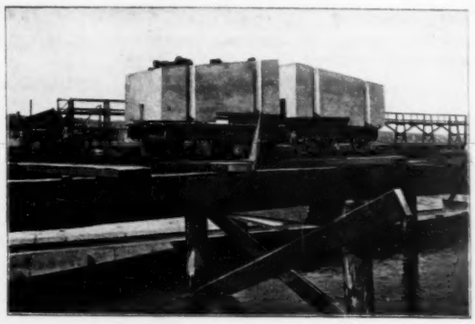


FIG. 6.—TRANSPORTING CONCRETE FOOTING BLOCKS FROM STORAGE YARD TO THE WORK.

FIG. 7.—TRAVELING DERRICK FOR SETTING CONCRETE FOOTING BLOCKS.

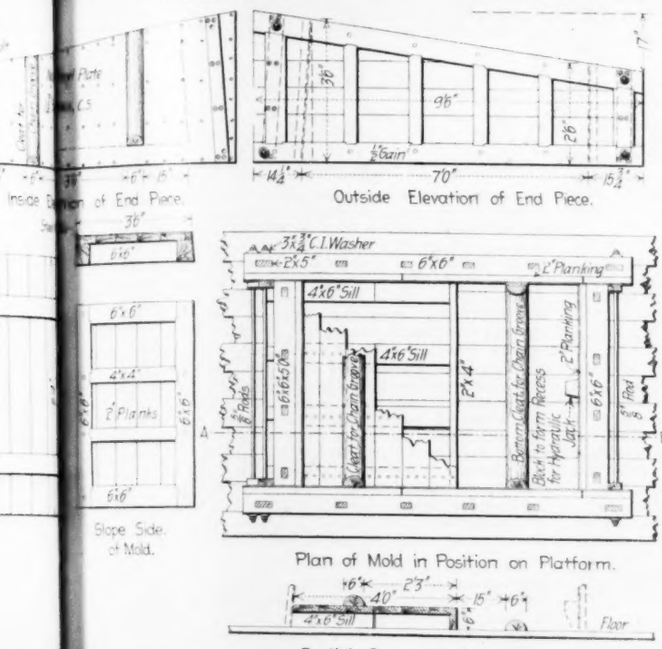

Outside Elevation of End Piece.
Plan of Mold in Position on Platform.
Slope Side of Mold.
Vertical Side of Mold
Partial Cross Section A-B
Floor

FIG. 2.—STANDARD MOLDS FOR MAKING CONCRETE FOOTING BLOCKS.

FIG. 8.—WORKMEN PLACING A CONCRETE FOOTING BLOCK.

MIXER

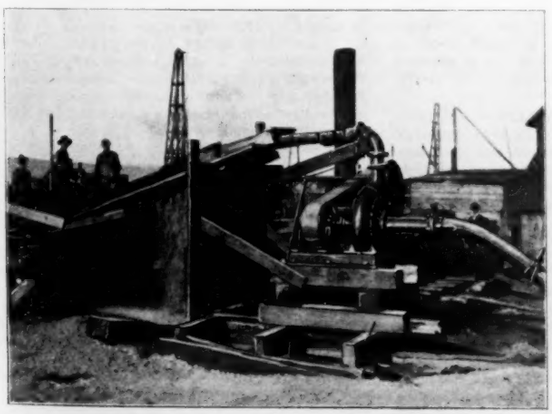


FIG. 4.—PLANT FOR PUMPING, WASHING AND SCREENING GRAVEL.

FIG. 9.—WORKMEN KEEPING THEIR FEET WARM WHILE WAITING FOR A BLOCK. (With Atmosphere at — 10° F.)

WORK SHIP CANAL PIERS, DULUTH, MINN.

ant Eng charge of Concrete Work. King & Steel, Duluth, Minn., and Charles Stone, St. Paul, Minn., Contractors.